

ASTRONOMY

November 1979

\$2.00

Saturn



Voyager 6001

ESCAPING THE LIMITS AND BEYOND!



As different as
Night and Day...
At Last — An All
Purpose Telescope!

First Came the Challenge:

Edmund Scientific ... you gave us Astroscan™ 2001; a revolution in Astronomy of historical importance and, according to experts, the greatest design and optical innovation ever in a reflector telescope of its size. Can you do it again? Can you combine the inventiveness of Edmund Scientific Engineering and the flawless quality of the Edmund Optical Manufacturing Facilities to create a **refractor** telescope of equal importance?

Then Came the Idea: Born from the challenge ... an idea brewing in the minds of the Edmund engineers and designers. Create a telescope for all purposes — a **refractor** telescope for all of the people ... a telescope full of purpose, wrought from the finest materials, designed for its simple beauty and the beauty of simple operation ... optically superb, portable, rugged and adaptable. A quality, multi-faceted refractor that will take you across wide plains, close in on the beauty of nature, offer intimate encounters with views far away — and at night, bring the thrill of outer space into equally sharp focus!

Now Comes the Reality: Proudly born of this fantastic concept ... a voyage from mountaintop to mountaintop; from water's edge to faraway horizons; from earth to beyond — **The Voyager 6001 Telescope.**



EDMUND SCIENTIFIC

Dept. K-22, Edscorp Building
Barrington, N.J. 08007

☐ YES! I would like to know more about the **Voyager 6001** Telescope. Please send me your all-new, FREE 1980 Catalog, today!



Name _____

Address _____

City _____ State _____ Zip _____

No. 139 © 1979 Edmund Scientific Co.

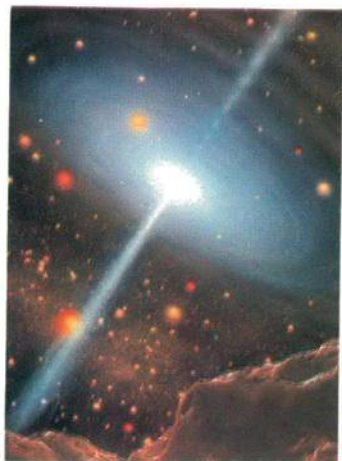
SPECIFICATIONS

Objective	60mm dia. f/8 achromatic lens; 486mm objective f.l.; 1.9 second of arc resolution; anti-reflection coated; superior quality; American made. 32X with 15mm RKE Eyepiece.
Eyepiece	The Edmund 15mm RKE® Eyepiece. Achromatic lens; 1 1/4" O.D.; 45° apparent field; completely ray-traced; American made.
Mount	Exclusive Edmund design. Lightweight, cast aluminum alloy table top tripod (protective pads on feet); altazimuth fork; cradle mount; high vibration isolation; detachable for easy mounting on camera tripod.
Special Features	Height: 13" (33 cm); Weight: Under 7lb. (3 kg); Tube Length: 18" (44 cm); Finder Scope: 5X 24mm refractor; Image Erector: Removable right-angle prism for astronomical use.



Edmund Scientific

New Posters From ASTRONOMY



1



2

Here's an inexpensive way to cover your wall with space — 6 exciting prints from the exclusive art collection of *ASTRONOMY*. Featuring superb reproduction in *ASTRONOMY*'s tradition, each of these posters speaks volumes about the grandeur of space and man's imagination.

We've added 4 new posters to our 2 most popular ones to create the selections you'll enjoy for years. Each poster is 15"x19", printed on heavy paper, and will be rolled in a tube to arrive unwrinkled and ready for your wall.

\$2.50

each

Set of 6 For \$12.00.



3



4



5



6

1. Radio Black Hole
by Adolf Schaller
2. Asteroid Miners
by David Egge
3. Tharsis Erupting
by Mark Paternostro
4. Zeta Reticuli
by John Clark
5. Black Hole
by Mark Paternostro
6. The Sun From Pluto
by James Hervat



Please order posters by name and artist
on the form bound into this magazine.

On September 1st this year, when Pioneer 11 arrived at Saturn, a milestone was reached in the saga of space exploration: All five planets of antiquity's solar system have now been visited by terrestrial spacecraft. Over the last 20 years, Pioneers, Mariners, Vikings, and Voyagers, each a surrogate for humans, have crawled outward from the Sun's third planet to seek, to observe, and to unfold.

These homely lumps of plastic, metal, and glass have shown us where this century's "Novae Terrae" are to be found. The past few years — to paraphrase a recent comment by planetary astronomer David Morrison — have sent back so much to us, it's as if Columbus, Magellan, da Gama, and Cook were all returning to port at the same time, laden with marvels.

Those steady, unblinking lights in the sky are becoming places, and the reconnaissance has just begun.



ASTRONOMY

Vol. 7, No. 11

November 1979

The World's Most Beautiful Astronomy Magazine • Established by Stephen A. Walther

Editor
Richard Berry
Associate Editor
Robert Burnham
Associate Editor
Dewey Schwartzenburg
Editorial Administrator
Katherine King
Production Manager
David A. Schwartz

President, AstroMedia Corp.
Robert A. Maas

Advertising Director
Robert Schmall

Comptroller
Dennis K. Wilk

Circulation Manager
Rosemary L. Pickart

Staff:
Jacquelyn Berger
Dianne Precourt Cuneo
Nancy Faustmann
Stephanie Kiel
Maggie Martinez
Bruce Precourt

Production Photography
Communi-Graphics, Inc.

Color Separations
Driscoll:Graphics Co.

Printing
E. F. Schmidt Co.

	6	Pioneer at Saturn
	16	Exploring the Image by David F. Malin
Forum	24	Eclipsing '79 Remember Viking? Stephen W. Hawking Galactic Orbit of Pioneer 10
Sky Almanac	34	Look Out for the Leonids
Photography in Astronomy	43	High Resolution Astrophotography by Steve Reed
Gazer's Gazette	53	The Moon: Mountains, Basins, and Scarps
In Focus	58	
Behind the Scenes	58	
Astronomy Reviews	62	
AstroNews	68	
Stellar Frontiers	78	Mass Loss from Stars by Robert E. Stencel
Astro-Mart	85	
Star Dome	92	Andromeda



Cover: In this issue, ASTRONOMY reports on Pioneer II's flyby of Saturn, the most distant of the planets known to the ancients. Visited by a spacecraft for the first time late this summer, the planet is also the next target for the two Voyager craft headed its way. Painting by Ludek Pesek. Facing page: Likely the best of the Earth-based photos, this image of Saturn was taken in 1973, when the rings were opened to their fullest. NASA/Lunar and Planetary Laboratory photograph.

ASTRONOMY (ISSN 0091-6358) is published monthly by AstroMedia Corp., 411 E. Mason St., P.O. Box 92788, Milwaukee, WI 53202. Copyright © 1979 AstroMedia Corp., all rights reserved. No part of this issue may be reproduced by any mechanical, photographic or electronic process or otherwise copied for public or private use without written permission of the publisher. Second class postage paid at Milwaukee, WI. POSTMASTER: When undeliverable, send form 3579 to publisher. Direct all inquiries, complaints, editorial submissions and other correspondence to ASTRONOMY, 411 E. Mason St., P.O. Box 92788, Milwaukee, WI 53202. Telephone (414) 276-2689. Not responsible for unsolicited materials. Please allow six to eight weeks for new subscriptions and changes of address to take effect. Due to the limited availability of back issues, new subscriptions must start with the most current month's issue. Cover price: \$2.00. Subscription price: 1 year, \$15.00. Canada & Mexico: add \$3.00 per year. All other foreign: add \$6.00 per year. Please remit in U.S. funds or equivalent. ASTRONOMY is indexed in *The Reader's Guide to Periodical Literature*. Microfilms of all issues of ASTRONOMY are available from University Microfilms, Inc., 300 N. Zeeb Rd., Ann Arbor, MI 48106 and Bell & Howell Company, Old Mansfield Rd., Wooster, OH 44691.



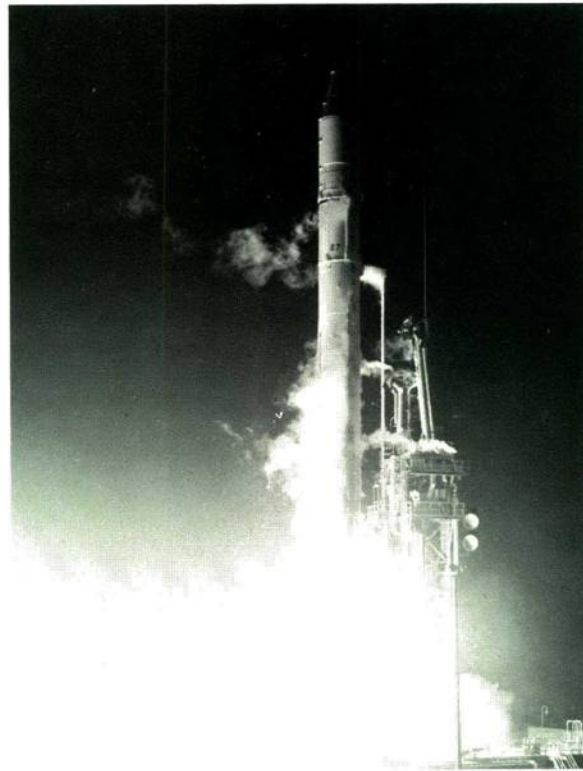
Pioneer at Saturn

Pioneer 11 was launched from Earth (Cape Canaveral) aboard an Atlas/Centaur rocket on April 5, 1973. The spacecraft's trajectory was chosen to take it past Jupiter on December 2, 1974, a year after its sister-ship Pioneer 10 made the same journey.

At the time of launch, space planners knew going on to Saturn with one or both craft was possible. But no one knew whether either Pioneer could survive the jovian encounter, and even if one did, there was no guarantee the hardware could endure the 6+ years in space that the "Saturn option" required.

As it happened, Pioneer 10 (targeted for Jupiter only) dove into the jovian system and exited triumphantly, its electronics a little fried by the trapped radiation in the magnetic field, but otherwise intact.

By the time Pioneer 11's final trajectory had to be chosen, the scientists and project staff felt that enough had been learned from Pioneer 10's encounter to make a duplication of its path unnecessary. Moreover, no one liked the idea of giving P-11 the dose of radiation that P-10 got; it had damaged the electronics and saturated the instruments with "noise," making the extraction of data difficult and uncertain. So, after much thought



April 5, 1973

and number-crunching, the decision was made: after Jupiter, on to Saturn!

P-11's trajectory through the jovian system — chosen partly because the resulting greater speed and shorter exposure time cut the radiation dose considerably — took it closer to the planet and deeper into the radiation belts than P-10's. In a magnificent piece of trajectory planning and execution, the craft made a loop around Jupiter that gave the instruments a good look at the jovian polar regions, then swung up out of the ecliptic and towards Saturn.

Climbing to a maximum of about 17° above the ecliptic (the plane in which the planets approximately orbit), Pioneer 11 coasted slowly around the Sun. In 1974 Jupiter and Saturn were about 120° apart as seen from the Sun, so the craft took four years — until this September — to reach Saturn. The Voyagers won't have as long a trip, since Jupiter has now moved much closer to Saturn: transit times for each are about a year and a half.

Pioneer 11 approached Saturn from "above" the ring plane, from the northern side. Because the Sun was on the southern side of the plane, the rings were seen lit from behind. From Earth we never see a view like this. Even when we are on the opposite

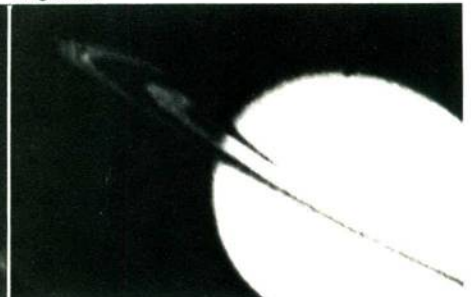
August 22

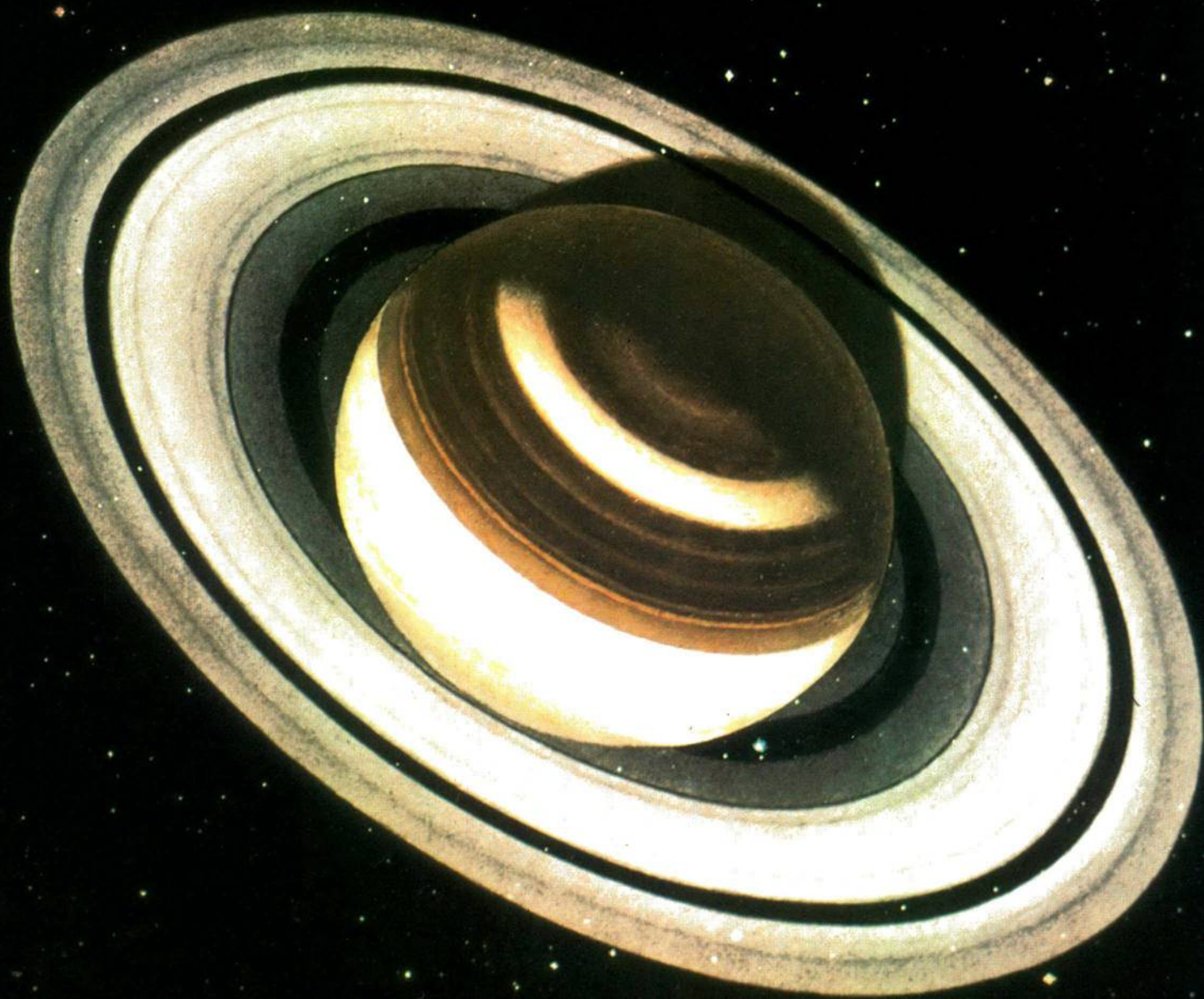


August 25

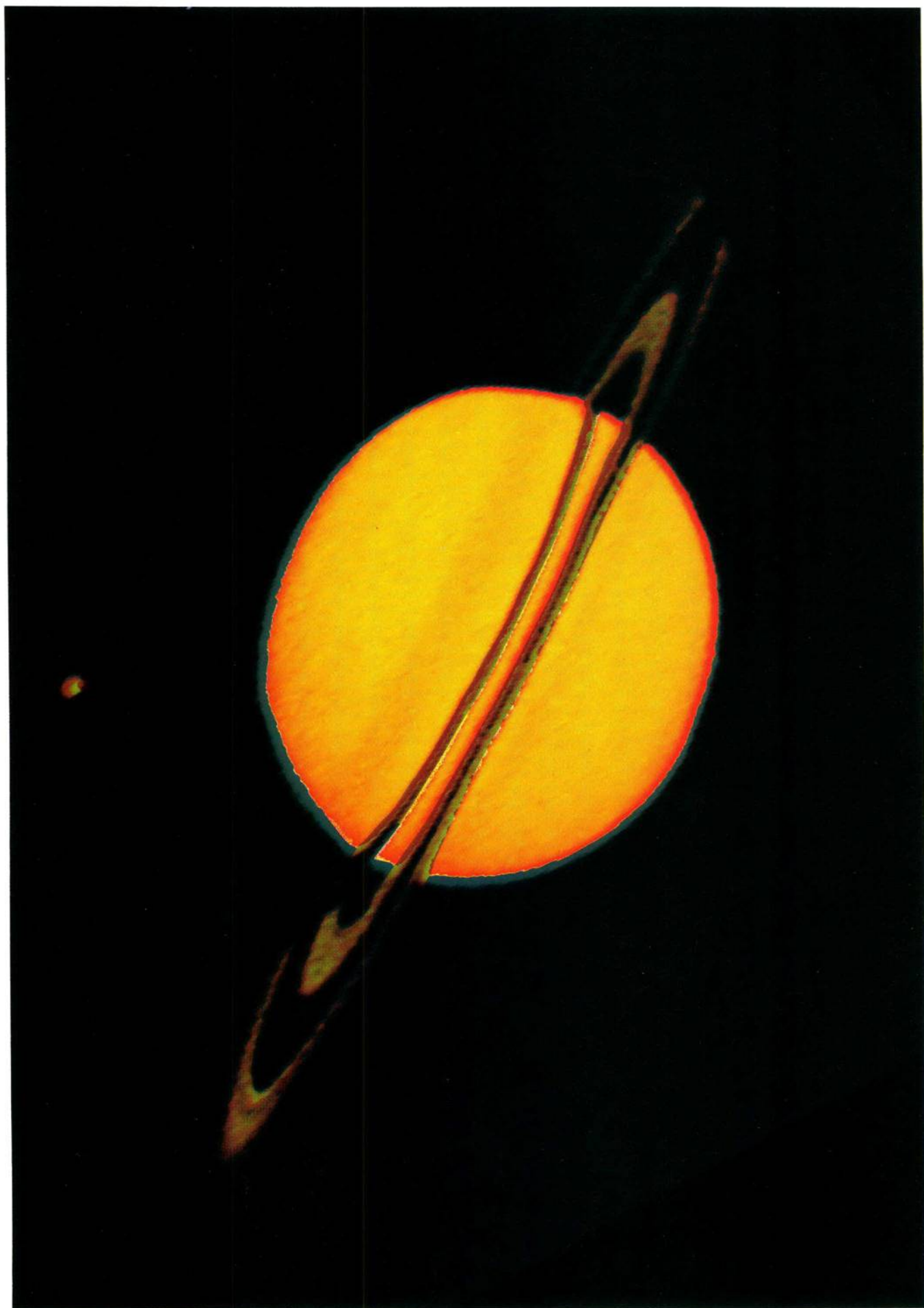


August 27





If we could see Saturn from well outside the rings, this is the spectacle we'd get. Outmost in the painting is the A ring; just inside that, is the dark Cassini Division, followed by the broad, bright B ring. Inside this lies the dim C ring. Pioneer has now shown us details in all of these, and discovered two wholly new rings. Painting by Donald Davis.



side of the rings from the Sun, the angle of tilt is so shallow that virtually no details are apparent. Pioneer has given us a wholly new look at the rings.

As it approached, P-11 was moving southward in the saturnian sky. At a distance of 14,200 miles (22,850 km) outside the edge of the A ring, the craft sped through the plane of the rings onto their sunlit side, moving swiftly under them toward closest approach, a short 2 hours later.

Its path bent by Saturn's gravity, Pioneer passed within 13,300 miles of the cloud tops. (To visualize this, think of Saturn as a 12 inch diameter beach ball. On this scale Pioneer came within $2\frac{1}{4}$ inches of the ball's surface.) Once past closest approach and moving outward, the craft rose back toward the ring plane, passing through it onto the northern (backlit) side of the rings 30,000 miles (48,500 km) beyond the outer edge of the A ring, just two hours after closest approach.

To a saturnian observer, Pioneer would have appeared to come from the general direction of the Sun. The inbound leg of its trajectory lay nearly in line with the Sun and Earth; the outbound leg was almost at right angles to this. All incoming photos show Saturn essentially full, while the outgoing ones reveal a view never before seen except in artists' renderings: a crescent Saturn.

What will be the fate of Pioneer 11 after Saturn? Its speed is well above solar escape velocity, so it cannot return: it'll continue outward from the Sun in the general direction of the constellation Aquila. Pioneer 10 is headed in the nearly opposite direction, towards Taurus, and is now beyond the orbit of Uranus. Radio contact with both spacecraft will be lost sometime in the late 1980s.

The famous "naked people" plaque attached to each craft is a recognition of their solar-escape trajectories; the designers hoped that any intelligent being finding it would learn something about the craft's makers: where and when they lived, and what they looked like.

Pioneer 11 Science

Saturn was expected (on the similarity of its gross characteristics) to be a "little Jupiter," but the situation has turned out interestingly different.

Magnetic fields and charged particles seem very remote entities, yet measurements of particles and fields are vitally important for giving planetary scientists a look at what's happening *inside* the planet, a region that cannot be directly examined. Knowing what the surface looks like isn't much help if you know nothing of what is operating in a planet's depths. Photographs and magnetic field measurements each provide only half the total

How different the rings appear when lit from behind! In this view, the Sun is behind the spacecraft and about 3° below the plane of the rings; the craft is about 7° above the ring-plane. The outer light band is the A ring. Inside the thin dark line (also part of the A ring — a particularly opaque part) is the bright Cassini Division. The broad dark band is the B ring; the inner light band is the C ring. The round dot is Titan.

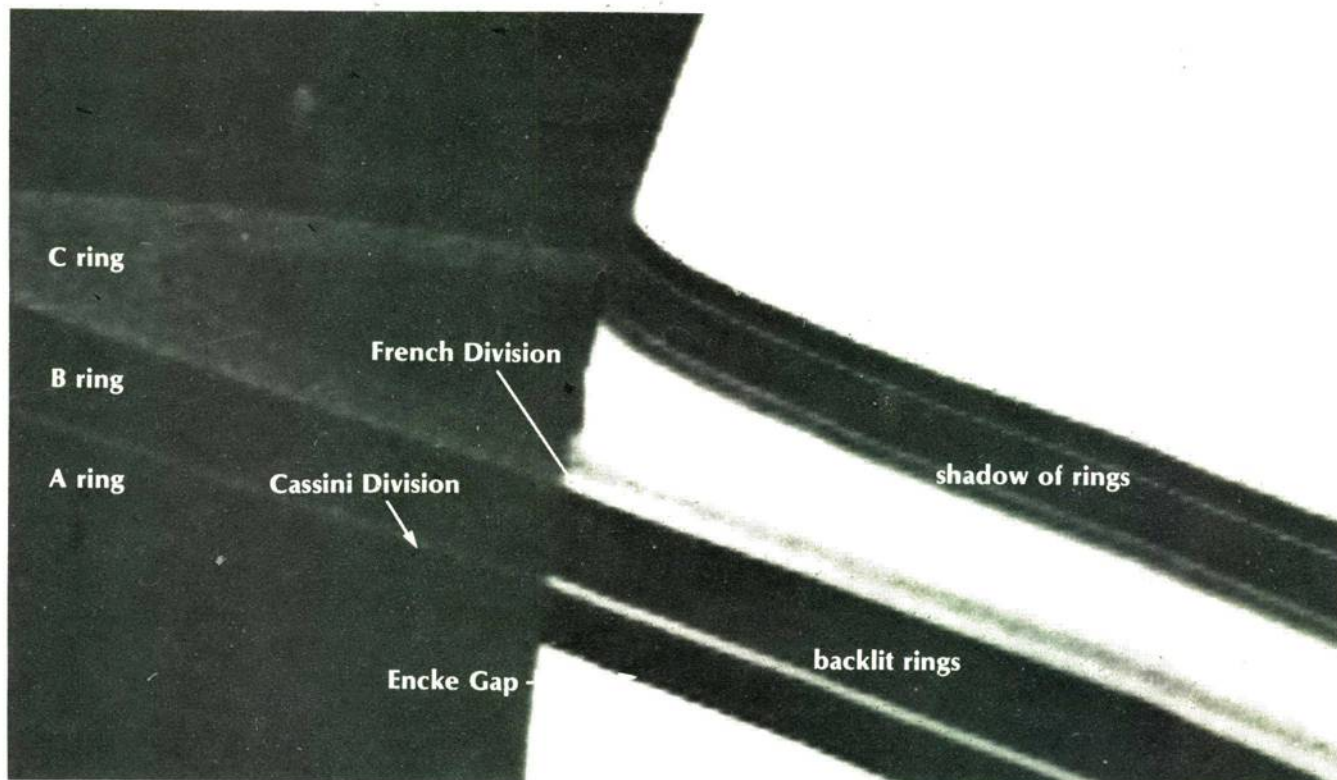


Titan was photographed only 5 times; this is the best image. You see hardly any detail, probably because this is the top of a relatively opaque atmosphere. (Remember how fuzzily tantalizing the Pioneer images of the Galilean moons were?) Computer enhancement in the months to come will pull out a bit more detail in the images, but we'll have to wait for the Voyagers to get a clear look at Titan or its atmosphere.

picture; lacking either, we'll end up with a very limited understanding of this extraordinarily beautiful planet.

The first finding P-11 made was that the strength of Saturn's magnetic field is far weaker than that of Jupiter: about $1/20$ as strong. The spacecraft did not reach the bow shock, the point where the planet's magnetic field is strong enough to deflect the impinging solar wind sharply, until it was about 15 to 20 Saturn radii away from the planet. (Jupiter's bow shock usually hovers further out — around 90 to 100 jovian radii.)

At the time of the Pioneer 11 encounter, the solar wind was very strong due to two separate events whose effects happened to combine. About a month prior to the encounter there was a strong solar wind event on the Sun which produced a vigorous flow of particles and radiation. This



Above: The backlit rings and their shadows on the planet are identified. Right: This picture (the color version of above) proved the existence of a long-suspected division between the B and C rings. Spend some time looking at this picture; note, for example, the structure in the B ring, the tiny thread of the Encke Gap, or the mottling in the C ring.

The Rings of Saturn

Our knowledge of Saturn's ring system has grown a bit, thanks to Pioneer. Here's an outline of the known rings and divisions, from planet outwards, together with their distances from the cloud tops:

D ring: Near cloud tops to 8600 km. Discovered by P. Guerin in 1969. Thin; not detected by P-11.

Guerin Division: 4000 km wide; lies between D and C rings. Not detected by P-11.

C ring: 12,600 to 28,800 km. Known since 1850; also called "crepe ring." Seen clearly by P-11.

French Division: Approximately 4200 km wide. Named informally by T. Gehrels, 1979. Existence argued for by French astronomers Dollfus and Lyot; confirmed by P-11.

B ring: 33,000 to 57,000 km. Known since invention of telescope. Seen by P-11 as almost opaque; densest of all the rings.

Cassini Division: 4800 km wide. Discovered 1675; known to contain matter; very bright when backlit.

A ring: 61,800 to 77,400 km. Known since invention of telescope; appears partly opaque, partly translucent. Ring divided by Encke's Gap.

Pioneer Division: 3520 km wide. Discovered by P-11; has little or no material in it.

F ring: Narrow (less than 500 km wide); at outer edge of Pioneer Division.

E ring: Exterior to F ring; outer extent unknown. Photographed by W. Feibelman in 1967. Not seen by P-11.

G ring: 571,000 km to 840,000 km. Detected on P-11 by decrease in electrons and protons; ring nature still tentative.

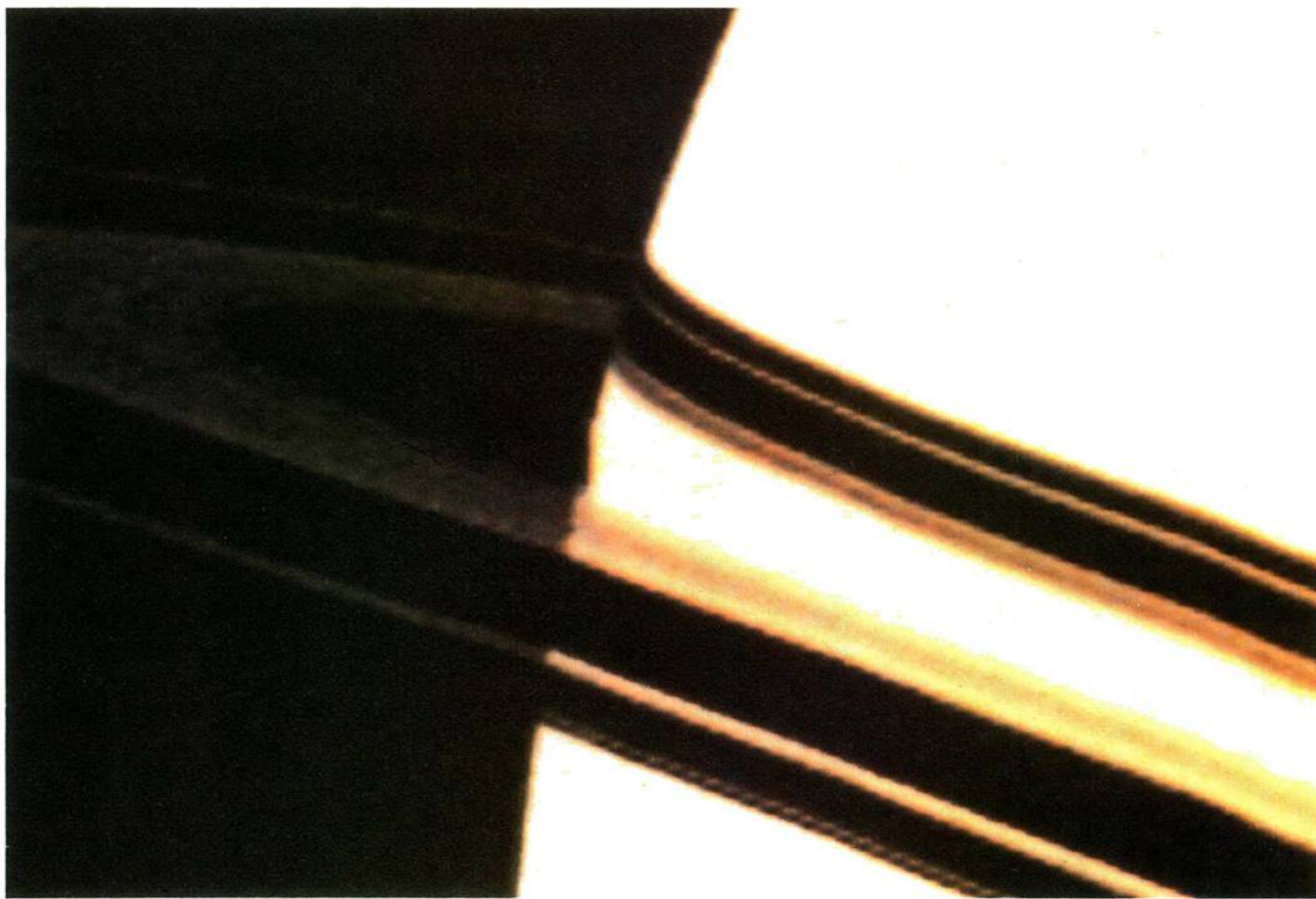
traveled slowly out and reached Saturn about the same time P-11 did. A week or so before the flyby of P-11, a solar flare happened that sent out a blast of energetic material — traveling much faster than the solar wind — which *also* reached Saturn at this time. The resulting particle pressure on the bow shock was about 10 times the usual, pushing the saturnian magnetic field in close to the planet.

The action of Saturn's magnetic field in the ever-present "breeze" of particles from the Sun is like a loose, springy mass of steel wool: when the wind gains strength, the field is compressed; if solar pressure slackens, the field immediately pops back out, pushing the bow shock farther away from the planet.

On the way in, Pioneer crossed this boundary several times as the bow shock was compressed and rebounded by fluctuations in the solar wind. On its outbound trajectory, at right angles to the incoming leg, the spacecraft exited through the side of magnetosphere.

Once inside the bow shock, the strength of Saturn's magnetic field could be measured: the field at the cloud tops at Saturn's equator is about half that of the Earth. Because Saturn is so much larger a planet than Earth, the total strength of the entire field is about 1000 times Earth's.

Yet the biggest surprise discovery — and one that makes Saturn unique among the planets known — was that the magnetic field is aligned with its rotation axis. On every planet having a magnetic field that we've examined with a spacecraft (Mercury, Earth, and Jupiter), the magnetic polar axis is tilted with respect to the rotation pole. For example, on Earth the tip is about



11°; with Jupiter not only is it tipped 10°, but it's also displaced about a tenth of a Jupiter radius away from the center. But on Saturn, so far as P-11 could measure, the tilt is *zero*. The Voyagers may revise this figure a little, but any tipping angle must be less than a degree. This presents quite a challenge to the theorists, because one of the most useful and reliable explanations for the existence of a field depends in part on the tilt angle to help generate the field.

Scientists think that a planetary magnetic field derives from currents flowing in the electrically conductive core of a rotating planet. The Earth has a conductive core of nickel-iron, while Jupiter and Saturn have massive layers of conductive metallic hydrogen surrounding small, rocky cores. With tilted fields, massive and conductive mantles, and rapid rotation periods, scientists expected to see magnetic fields on the gas giants stronger than Earth's — and indeed these have been found. Pioneer's results, however, still showed a relatively strong field on a planet without a tilted field. It's clear changes in the present model need to be made, but it's too soon to say just how.

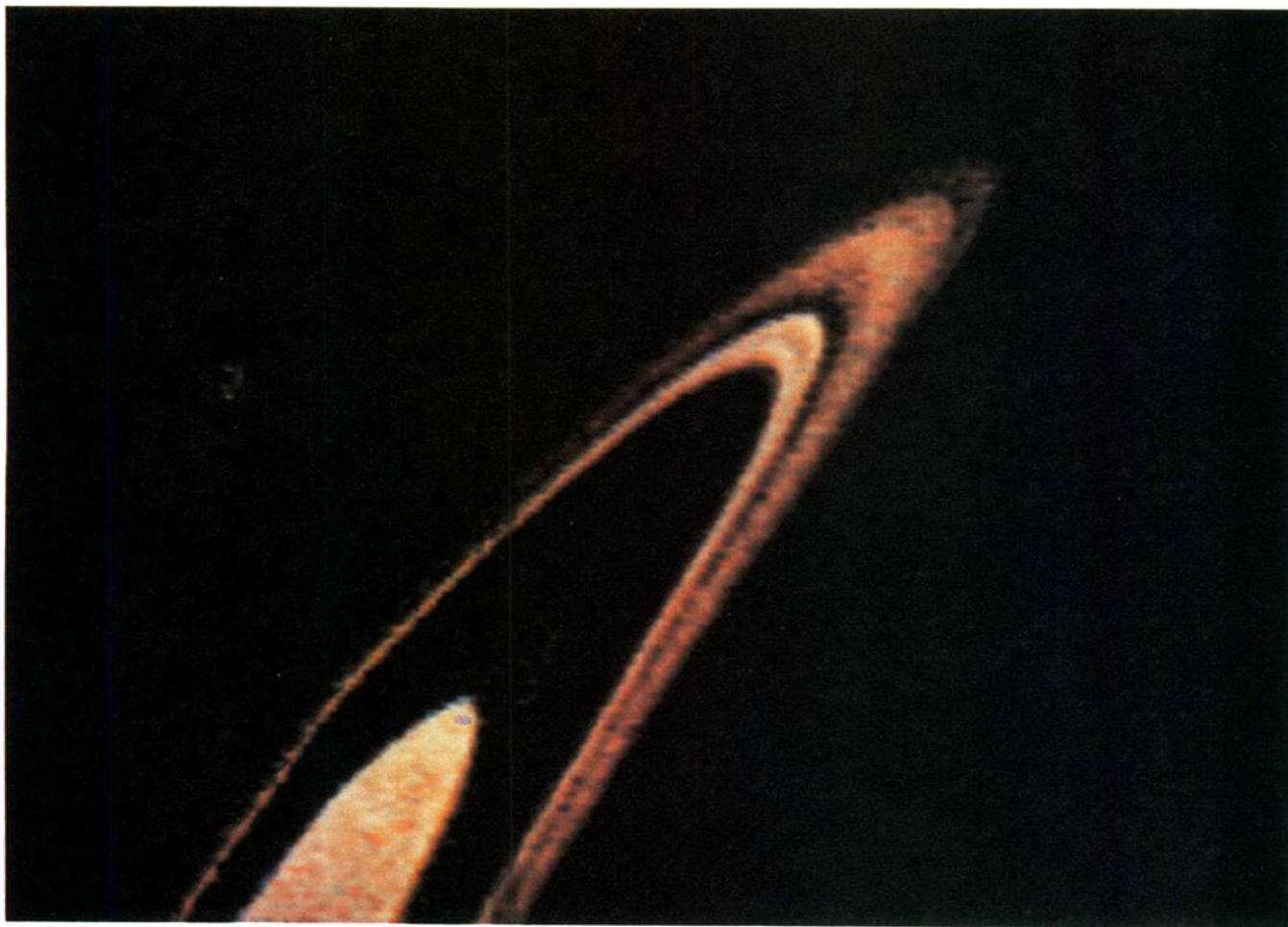
Trapped by Saturn's magnetic field are an enormous number of protons and electrons from the solar wind. Contained by the field lines, they spiral round and around, emitting radio noise. The particles closest in, those with the highest energies,

finally crash into the rings. Because of this, Saturn's particles never reach energies as high as Jupiter's, so the radio howl they make isn't as strong. Yet the radiation fields at Saturn are undeniably powerful.

The trapped radiation belts at Jupiter were the spacecrafts' greatest danger, as they were very strong. At Saturn, however, their relative weakness put the instruments to no risk. ("Weak" is relative here, since the radiation is strong enough to kill an unprotected human.)

As Pioneer 11 headed into the system, it measured the numbers and energy of these particles, broadcasting back how their strength varied with distance from the planet. Astronomers plotted the numbers, and out of these esoteric measurements came the surprising discovery of a hitherto-unknown ring, provisionally labeled the G ring.

On the inbound leg, the scientists saw a small dip in the particle count, but under the pressure of the mission, it was largely ignored. Then, closer to Saturn, they noticed how totally the ring system acted to absorb particles ("the guillotine effect"). The particle counts made during the flight under the rings, in fact, were lower than at any time since P-11 was sitting on the launch pad at Cape Canaveral! With this effect in mind, they looked again at the measurements made as P-11 approached the system. And there, starting about



850,000 km (520,000 miles) outside the A ring, they saw the dip in the number of particles. After some thought, calculation, and a little surprise, they came to the conclusion that this was evidence of a new ring, the first ever discovered this way.

Closer in, another sudden drop in particle density confirmed the existence of a new moon spotted also by the imaging system. The moon, informally dubbed "Pioneer Rock," is about 200 km in diameter. The spacecraft missed it by about 2500 km — an unbelievably small margin by interplanetary standards and far too close for comfort. When Pioneer zipped past, the particle count dropped sharply in the moonlet's wake, because the rock sweeps up everything in its path.

How Hot Is Saturn?

One very important job for Pioneer was determining the heat budget of Saturn, that is, helping scientists account for the radiation it receives from the Sun and measuring what energy it gives off. Any excess radiated away above what it receives must come from an internal source. Pioneer found that Saturn radiates about $2\frac{1}{2}$ times what it receives from the Sun. The internal heat source may be residual warmth left over from its formation $4\frac{1}{2}$ billion years ago.

The heat-detecting instrument, an infrared radiometer, found a good deal of variation over the face of the planet as the belts and zones differed

Above: This is perhaps the best close-up of ring detail. With the help of the key on page 10, you can pick out the various components. **Right:** An imaginary landscape on Saturn's third moon, Enceladus. The little moon near the rings at upper right is Mimas. Painting by David Egge.

slightly in temperature. In general, the darker belts are warmer by about 5° Kelvin than the light zones; the temperature of the atmosphere top on average is about 95° to 100° K (-300° Fahrenheit). These results will help the theoreticians who work on atmospheric circulation build structural models of Saturn's outer layers. When they look at how surface heat is distributed, the scientists can probe below the visible surface with mathematical models.

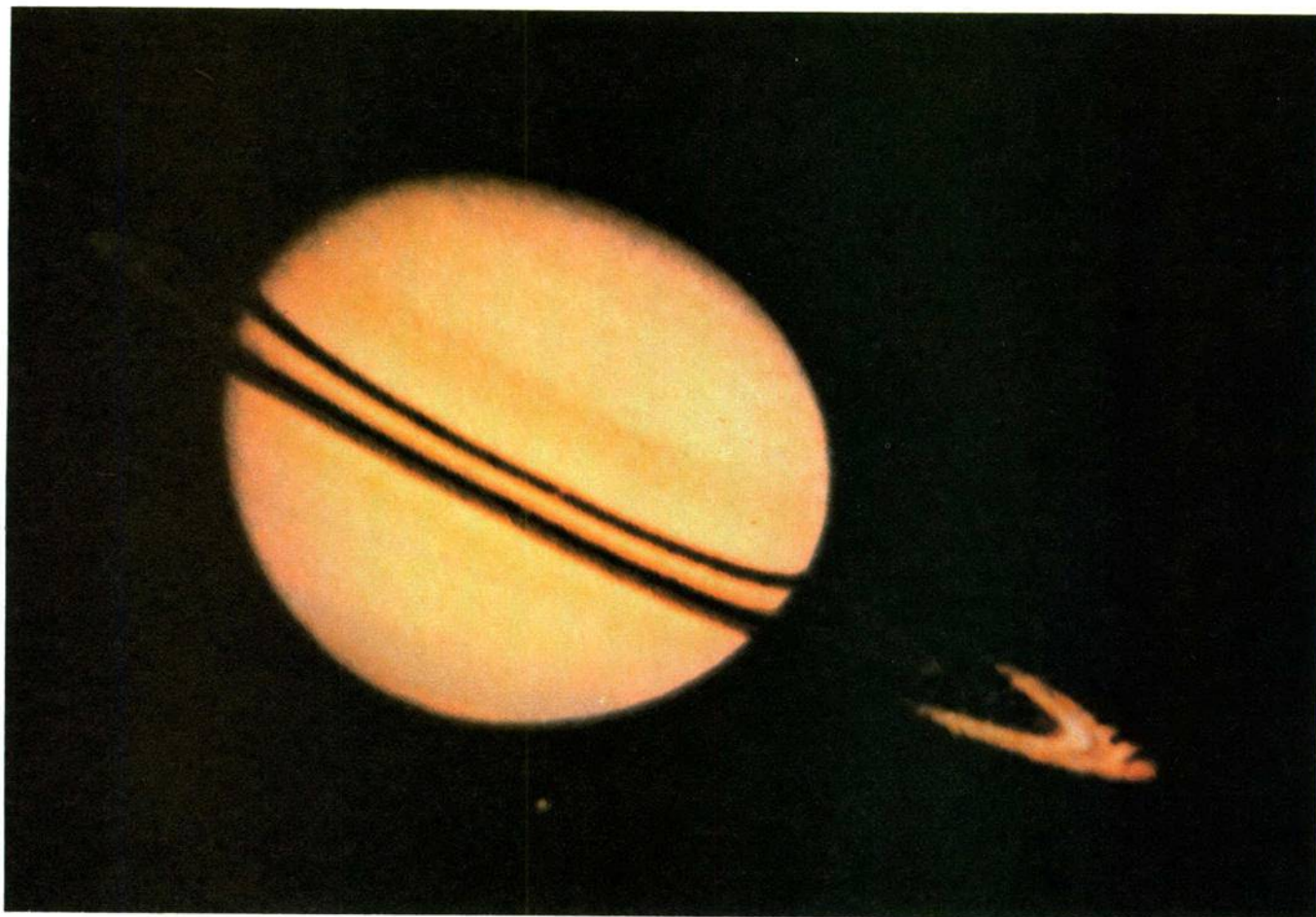
By examining the cooling rate of particles as they orbit into Saturn's shadow, the infrared instrument showed that the ring particles are smallish, in the centimeter to inch size for the most part, and are either solid water ice or coated with an icy layer.

Titan

The big disappointment of this flyby was in connection with Titan: the noise in the returned radio signal was too great for detailed measurements to be extracted. The hoped-for result was temperatures on the day and night sides of Titan. A reliable measurements of each would have made a lot of difference in the proposed models for



Egge ©
Sept. 2 1979 AD.



Titan's atmosphere — and any chances for finding life there. The top of Titan's atmosphere is about 75° K, but what the surface temperature is still remains unknown, at least until the Voyagers take a look.

Basically, the scientists hoped to distinguish between two atmosphere models: one having a thick atmosphere like Venus, the other with a thin, Mars-like one. If the thick-air version is true, then the day/night temperature difference will be small. This implies a thick atmosphere, lots of warmth and pressure, maybe even liquid water, and possibilities for biology. On the other hand, if the temperature difference is great, then the atmosphere is thin, which implies a cold surface with little or no pressure, and water (if any) would be frozen: all very bad news for biology. Unfortunately, Pioneer couldn't tell us which is the case for Titan.

Images

While the Titan data were disappointing, the imaging part of the mission more than fulfilled its promise. Considering this was a machine designed to make only about 10 pictures of Jupiter after two years in space, it's remarkable, after 6½ years, that it worked at Saturn. The results over the entire course of the mission have been impressive.

Of course, the photos suffer by comparison with those from Voyager ("This is a particles-and-fields mission, not an imaging one..."). The picture-taking instrument on Pioneer is an "Imaging Photo-

Polarimeter," not a TV camera. It looks out to the side of the spacecraft, measuring light from a very narrow angle and uses the craft's 7 r.p.m. stabilizing spin to scan across the desired object.

In addition, the device can point forward and back along the spin axis, thus building up an image over a number of spin-scans, each of which contributes a tiny thread of light to the image. When these threads of light are assembled (the spacecraft does "bookkeeping" on each scan, noting where the instrument was pointing and when), the result is a picture.

After the light comes into the instrument through the lens, it goes into a beam-splitter that sends part of the light through a red filter and part through a blue one. (There is also a special filter that detects polarization.) The craft then radios back to Earth the brightness of each element of the scan-line in each color. On a computer-driven TV screen, two separate images are built up, one red, one blue. A "fudge-factor" third color (yellow) is necessary to make a true image; just enough is added to make the picture resemble earth-based photos of the planet.

Over the next few months, the imaging crew at the University of Arizona will be working on getting the best possible photos out of the returned signals. All the photos have some "noise" in them and need contrast-enhancing to bring out more details.

Saturn and its moon Rhea (on the right) are seen here. The distortion comes from uneven spacing of the scan lines, and the brightness increase toward the right side is caused by changing the instrument's "exposure control."

The imaging system found another ring (the F ring), detected a possible 11th or 12th moon, and confirmed the existence of a long-suspected division between the B and C rings. In addition, the images of the backlit rings (when the astronomers get some time to analyze the data) will prove very useful as they determine how thick (physically and optically) the rings really are and work out details of their structure.

Telescope observers who've spent time gazing at Saturn's rings are particularly intrigued to see that the brightest "ring" in the backlit images is the "dark" Cassini Division! Although this gap between the A and B rings looks dark to terrestrial observers, earth-based studies — carried out with great difficulty — had shown there was *some* material in the Division, though very little. Lit from below, the Division appears very bright because the particles in the Cassini Division happen to be very efficient at scattering light. This scattering property means they must be about the same size as a wavelength of light.

The moonlet seen ("Pioneer Rock") may (just possibly) be Saturn's 10th moon Janus, *or* it could be the hypothetical 11th moon proposed on dynamical grounds several years ago, *or* it could even be an altogether new object. It's difficult to decide because Janus was discovered in 1966 when the rings were edge-on to the Earth, but hasn't been seen since due to glare from the rings. Its orbit, therefore, is poorly known. To clear up irregularities in the observations, some astronomers proposed that Janus was actually two moons: Janus (S-10) and a new "S-11."

Currently, we on Earth see the rings about edge-on again. Three passages through the ring-plane occur between October 1979 and July 1980, and intensive ground-based observations may settle the question of just what it was that P-11 saw.

The new division between the B and C rings has been provisionally called the "French Division." Several observers at Meudon and Pic-du-Midi Observatories in France had detected it in the 1940s, but other observers couldn't confirm it.

Ringbits

Pioneer's trajectory was chosen in part to investigate the safety of spacecraft passing through the ring-plane just outside the A ring. Pioneer's survival showed the way was clear for Voyager 2, which must pass through this area if controllers select the Uranus option.

Nor was this just an academic exercise in speculation. There *was* a very real possibility of Pioneer "getting snuffed in a hail of icy bullets," since Earth-based radio and radar studies had shown material in the region P-11 had to fly through.

For each Pioneer image shown on these pages, this table gives the date taken and the distance between the spacecraft and the object. The picture number is NASA's designation and specifies the image uniquely in their files. (All picture numbers have "A79-" as a prefix.)

Page	Date	Range (miles)	Picture #
6 (L)	Aug. 22	5,180,000	9101
6 (C)	Aug. 25	3,420,000	9102
6 (R)	Aug. 27	3,390,000	9103
8	Aug. 29	1,760,000	9105
9	Sept. 2	230,000	9059
10 & 11	Sept. 1	245,000	9120
12	Aug. 31	586,000	9111
14	Aug. 29	1,600,000	9107

Robert Burnham, of ASTRONOMY's staff, went to NASA's Ames Research Center in Mountain View, California, to cover the flyby. All photos listed above are courtesy of Ames and NASA; Ames Research Center manages and controls the Pioneer spacecraft for NASA's Office of Space Science.

The crucial questions were "How much?" and "How big?". No one was really worried about Pioneer's fate if the particles were big (say, Volkswagen-sized), since then they'd be far enough apart to make a hit unlikely. And if they were very, very small (dust-sized), then the chance of a hit was certain — but they'd be so small they'd only scour the craft, leaving it basically intact. The danger came from millimeter-sized particles: These were both common enough to guarantee a hit and large enough to do real damage.

But all went well. Five small hits were recorded on the micrometeoroid detector: two before ring-plane crossing, one between that and closest approach, and two while it was behind Saturn and before the ring-plane crossing on the way out. It is possible the device was "saturated" by hits (it records only 2 at a time, then shuts off for 80 minutes as it resets itself); further study over the coming months will establish how many hits were statistically likely to have happened while the machine was ignoring them. But the way looks clear for the Voyagers to come roaring through.

Pioneer

The names given to spacecraft often seem uncomfortably close to those chosen for automobile models, but Pioneer couldn't be more appropriate. Lost in the hoopla surrounding the Voyagers and the upcoming Galileo mission is the fact that the more spectacular missions wouldn't be possible if some spacecraft hadn't tested the route before. Pioneer 11 even literally "led with its chin" to check out the ring-plane crossing.

This is the last of the Pioneer-class spacecraft. When Pioneer Venus falls silent, there'll only be the ever-fading whisper of signals trickling back from the depths of the solar system to mark the passage of these craft. And then that, too, will be gone. ☛

Exploring the Image

by
David F. Malin

Electronic image detection has not yet replaced photography in astronomical research. Despite ultra-sensitive television cameras, solid state diode arrays, and image tubes now available, today's research astronomers often still choose the not-so-humble photograph.

Why? Modern photographic emulsions combine several important abilities. First, they are large, capable of recording the entire image area of a large telescope. Most electronic detectors are still small. Second, although not as sensitive as the best electronic methods, they require no special treatment to work well. Electronic detectors often must be kept very cold. Third, they can collect light over long exposures. Some electronic devices can do this, but none combine all three special abilities.

Photography is a simple, low-cost system providing a permanent, easily-copied record of light from far ultraviolet wavelengths to the near infrared. No other detector can do this and still remain compact and convenient to use.

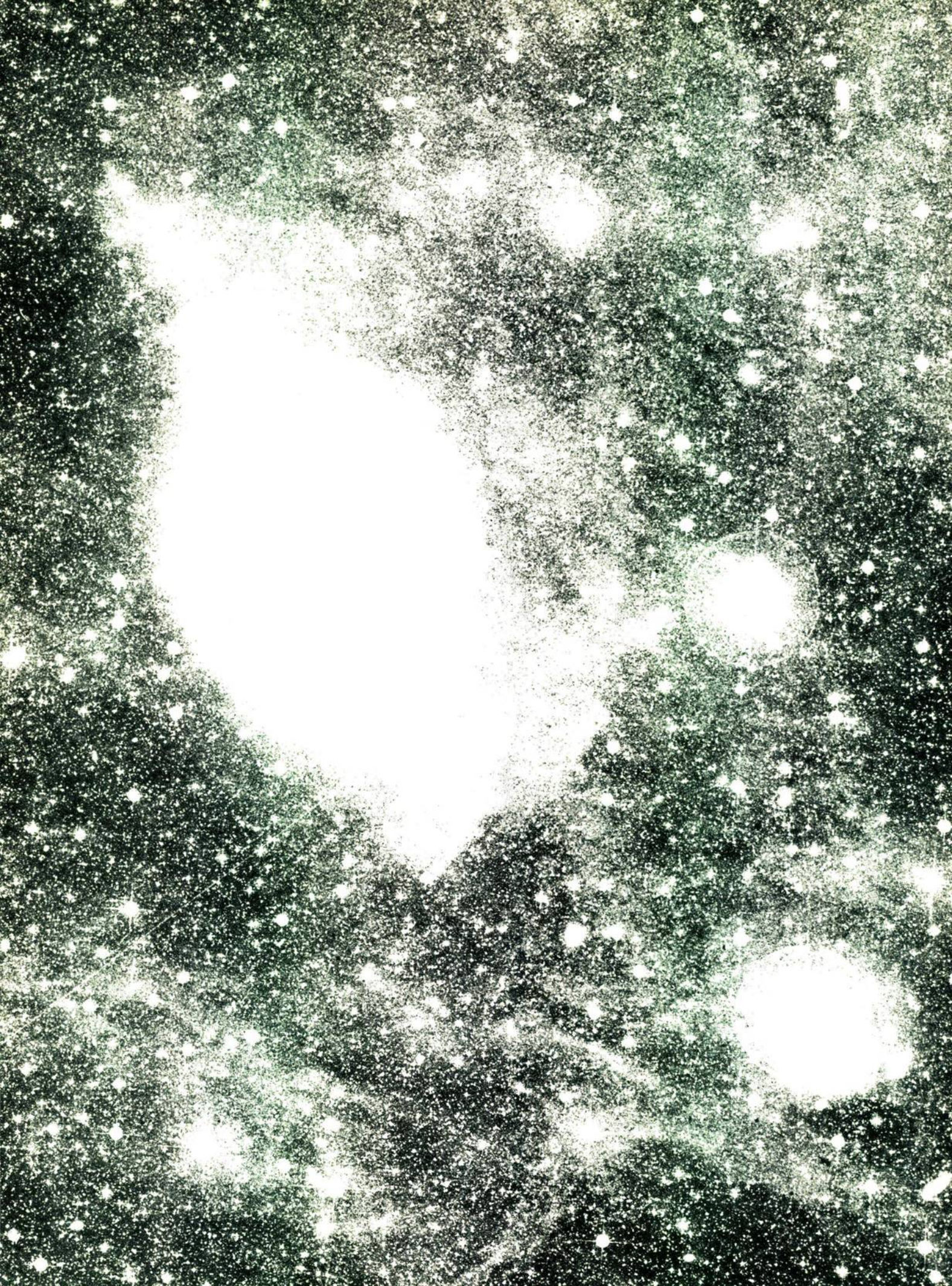
For many years Kodak has supplied a comprehensive range of photographic emulsions coated on glass plates to all the leading observatories of the world. Two fairly recent new emulsions have given astronomers the ability to record fainter objects, and are now used on the world's largest telescopes to probe the most distant parts of the universe. These emulsions, blue-green sensitive IIIa-J and red sensitive IIIa-F, are designed to provide very fine grain with high contrast and resolution. These emulsions are ideal for photographing very faint objects against the glow of the night sky, and they're especially suited for use on large Schmidt cameras.

To obtain their full sensitivity, the astronomer must hypersensitize the plate shortly before use. This involves bathing the plate (in total darkness, of



course) in certain liquids or gases. After being hypersensitized, these fine-grain plates give exposure times comparable to the old fast but grainy plates. Sky-fog limited exposures take about

The strong radio galaxy known as Centaurus A shows different aspects when photographic wizardry is used. Both the normal print (above) and the enhanced contrast print (right) are made from the same plate and are reproduced here at the same scale. The galaxy's true and vast extent is revealed for the first time. All photos copyright © 1979 Anglo-Australian Telescope Board.





Above: M-89, an elliptical galaxy in Virgo, shows an eruptive jet when a deep photograph of it is contrast-enhanced. Below: The usefulness of another technique is shown with two photographs of M-83. By reducing contrast in the print, the burned-out central regions display knots of gas and tangles of dust while dim details in the outer rim are retained.



an hour on telescopes with focal ratios around $f/3$.

To record the faintest possible images, the IIIa emulsions are exposed long enough that the sky background develops to a very high density, which gives maximum contrast. Such sky-limited plates are very dark — often darker than the darkest areas found in the highlight areas of conventional negatives — but this is essential if the faintest images are to be recorded. The dense background combined with the very high contrast has encouraged astronomers to look for new ways to extract the astronomical information recorded on these deep plates.

Two simple methods, developed in the photographic laboratories of the Anglo-Australian Observatory, can be applied to all photographic negatives, but are especially suited to deep exposures on IIIa emulsions. The methods are complementary — one is aimed at revealing the faintest images while the other extracts useful information from apparently overexposed parts of the plates. Together the techniques explore for the first time the full potential of modern astronomical materials.

Copying

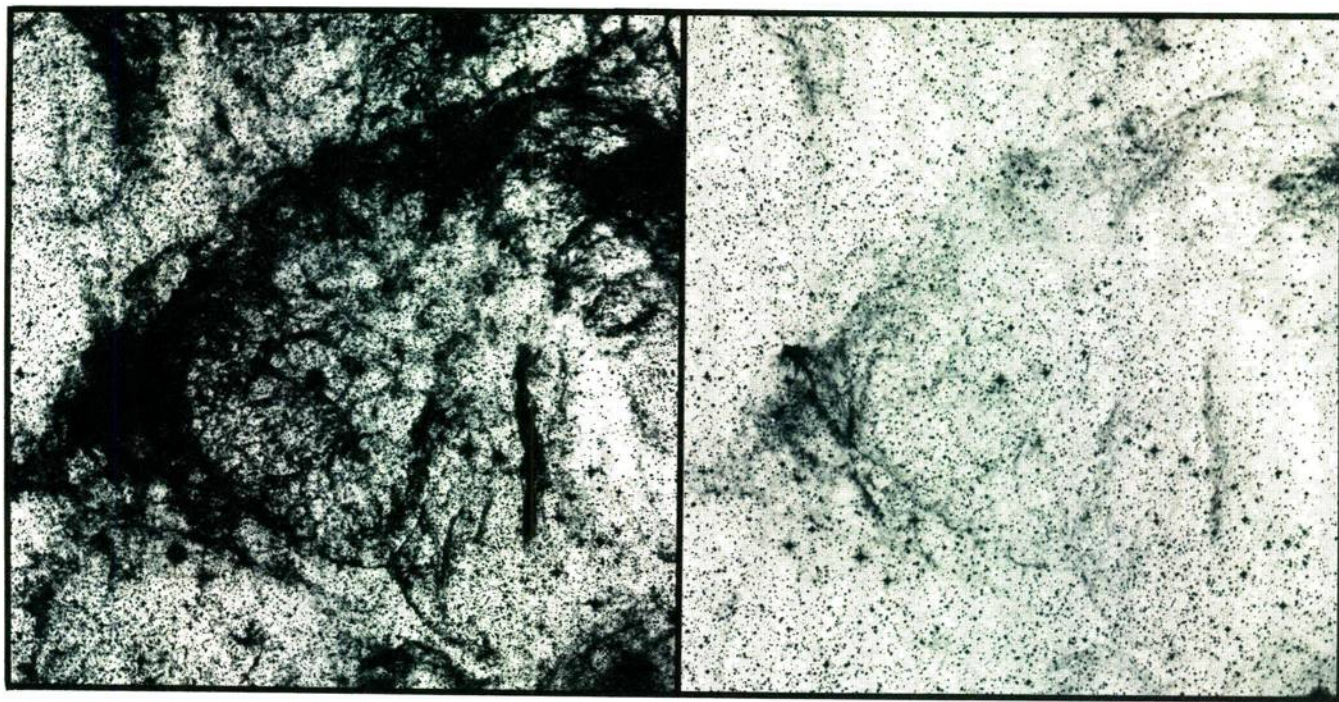
Photographic plates are a three-dimensional recording device. In addition to length and breadth, the coating layer has a finite thickness, typically 0.1 to 0.2 millimeter. The faintest images (signals) are found in the uppermost layers of the developed emulsion, whereas grains due to chemical fog (noise), unavoidably present in hypersensitized plates, are distributed at random throughout the full depth of the coating.

Usually copying astronomical plates is done with more or less parallel beams of light from a distant point source or in an enlarger. In either case, grain from the total thickness of the emulsion is projected sharply onto the copy film. But if the plate is copied under diffuse light, however, only the grains near the surface (the ones carrying the image) are copied sharply; those deeper in the emulsion (the noisy background) are diffused out. The net result is an amplification of the faintest images with a reduction of noise.

Agfa-Gevaert graphic arts film type Fo71p seems to be the ideal copy film for this work. The emulsion has built-in developer components for machine processing but we develop it for about 2 minutes in standard print developer after an exposure chosen to yield a rather thin-looking positive. Enlarged or contact printed onto hard (grade 4 or 5) bromide paper, the copy reveals the faintest images on the original plate. The method gives negative (i.e., black star) pictures, preferred by astronomers for locating faint images. A further contact copy on film of normal contrast yields a true positive image.

Complex interactions among members of the Virgo Cluster of galaxies were suspected, but this photo, suitably enhanced, reveals the bridges of gas and dust between the objects.





The nearest radio galaxy, Centaurus A, is shown on page 17. A normal copy of the same object, made from the same original plate and to the same scale as the main picture, is opposite. Centaurus A is revealed to be over a degree across, more than twice the apparent diameter of the full moon. Some of the faint nebulosity may belong to our own galaxy and be quite unconnected with Centaurus A, though the extreme faintness of the filaments makes this difficult to confirm. The original IIIa-J plate was a 70 minute exposure on the 1.2 m U.K. Schmidt telescope.

Another startling result to emerge from amplifying U.K. Schmidt images was the detection of a large jet associated with M-89, a bright elliptical galaxy and prominent member of the Virgo Cluster. About 1° away from the well-known X-ray and radio source M-87, M-89 has a series of concentric shells associated with it which may be connected with the violent events producing the jet.

It could be that M-89 is a run-down version of M-87 (see page 18, top), its energy expended in ejecting the jet and shells. The outer rim of material to the northeast (top left) is probably the faintest object ever detected by direct photographic techniques. The picture was made by adding together contact positives made from two deep IIIa-J U.K. Schmidt plates.

On the other hand, a single plate was used to show the extent of the large elliptical galaxies M-84 and M-86 at the heart of the Virgo Cluster (page 18, middle and bottom). In the upper print (made by the copying process) M-86 (center) is seen to be much the larger galaxy, its slightly disturbed outer envelope appearing to merge with its near neighbor, M-84. Many low surface brightness objects are revealed which are invisible on the normal copy made from the same plates (below).

Above: The tangled luminous wisps of gas left over from the Vela supernova were well-known from conventional prints. But by enhancing the contrast, many more wisps, often at the limit of detectability, were brought out clearly. Above left is the enhanced version (in negative); above right is the conventional print (likewise). Opposite page: The enhanced version printed as a positive.

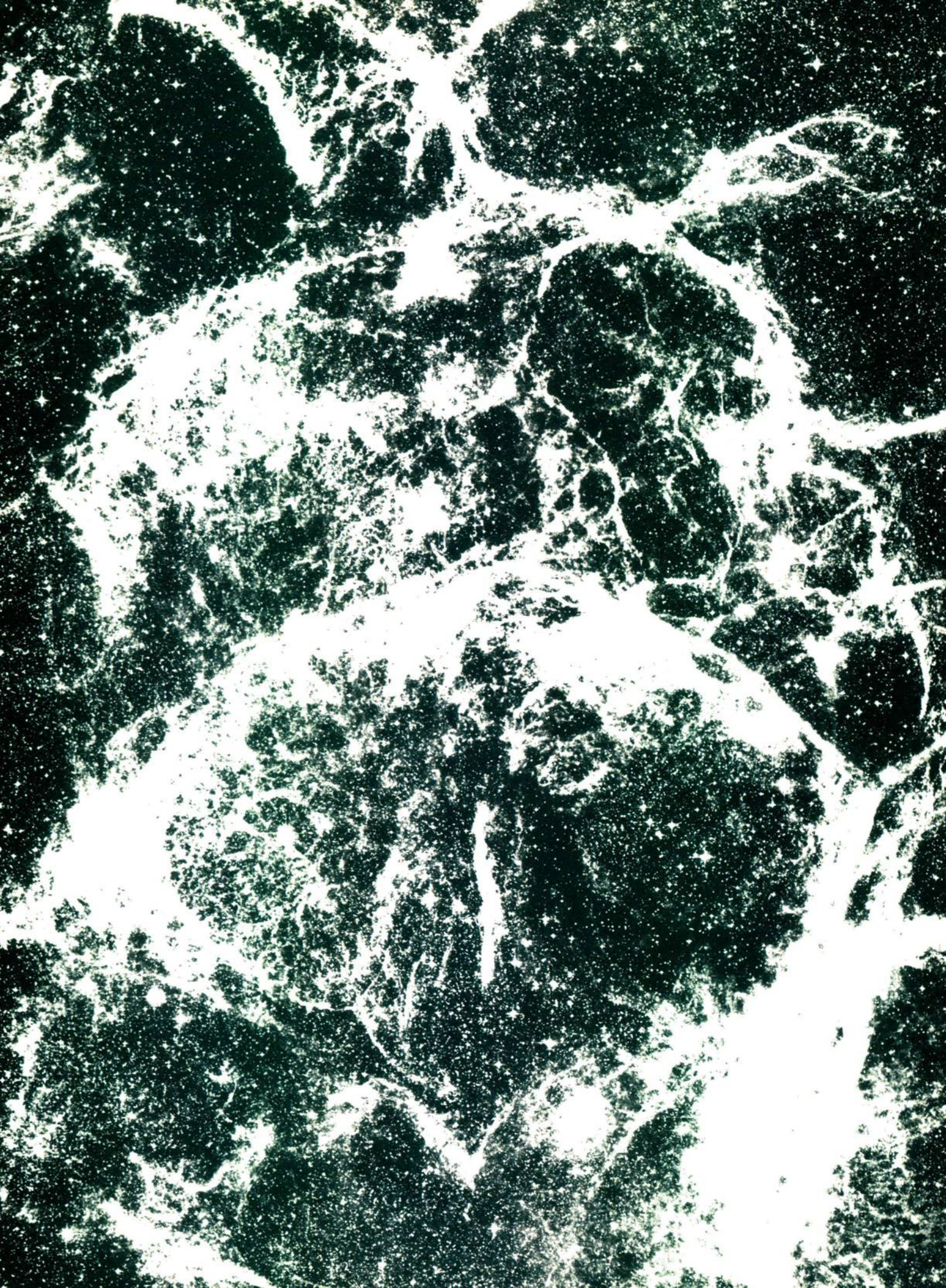
This photo also shows a very uniform sky background, the result of meticulously-careful processing of the original 14" square plate. Care is a must since the process will tremendously amplify any irregularity or sloppiness in the darkroom work.

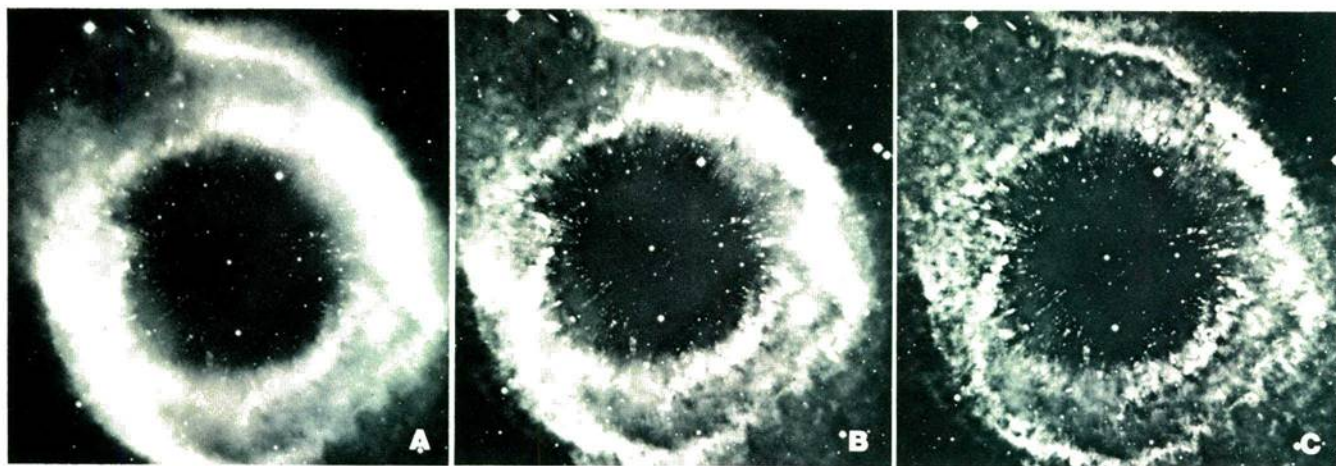
An explosive outburst much nearer home produced the Vela supernova (see page 21). Lost in the nebulosity is the Vela pulsar, a rapidly spinning neutron star created in the same supernova explosion and recently detected optically by the 3.9 m Anglo-Australian telescope. A normal copy of the 90 minute IIIa-F (U.K. Schmidt) plate is alongside the amplified version which shows for the first time very faint filamentary structure in the expanding shell of ionized gas.

Masking

A fully exposed and developed IIIa plate encompasses an enormous range of photographic densities, much greater than those found in normal negatives of conventional subjects. The densest parts of some plates will transmit less than 1/10,000% of the light falling upon them. And yet these extremely dense regions still contain useful — but hidden — images. By using another copying technique, astronomers can dig out detail from the blackest parts of plates without losing the fainter images that are only slightly denser than the sky background fog. It sounds wildly impossible, but isn't.

Start by making a contact copy of the original negative onto film of normal contrast using a





diffuse light source. But instead of a normal emulsion-side to emulsion-side copy, make the positive with the copy film in contact with the *back* of the glass negative. (Films can be worked by attaching them to thin glass plates.) After processing, you will have an out-of-focus positive blurred by the spread of light in the thickness of the glass.

Put the dry, processed positive in contact with the back side of the plate and now make a contact copy of the original, emulsion-to-emulsion in the normal way. In order, the sandwich layers are: light source, mask, original, print. (Alignment of the mask isn't critical but register marks on the back of the plate are helpful.) Increase the exposure to allow for the density of the unsharp mask.

After processing, you will find that the mask has filtered out most of the large-scale density variations of the original and left a copy with detail in even the blackest parts of the negative.

It takes practice to work out the exposures and processing conditions for masks to suit all your negatives, and some means of measuring densities is useful for precise applications. However, even the simplest kind of mask will produce remarkable results from the most intractable negatives and this is where experimentation can be very rewarding.

The effect of two different unsharp masks is shown above on a deep plate of the planetary nebula NGC-7293 (the Helix Nebula). The first illustration (A) is a print made directly from the original plate on the softest available paper. The distinctive radial filaments pointing towards the central star are barely visible. A mask which removed about half the density range of the plate was used to make print B which reveals some detail in the outer shell of gas. In print C about 85% of the original density range was removed by the mask.

Faint nebulosity at the ends of the oval is retained together with detail in the brightest parts of the "helix" itself. The radial streaks extending through the gaseous envelope are clearly delineated and faint background stars and galaxies can be seen. By lowering the density range in the larger structures, the mask allows the contrast of fine

At times you want to reduce contrast to preserve details. Above are prints of the Helix Nebula (NGC-7293). At the left is a soft print, in the middle is one with about half the contrast range, while the one at right has only about 15% of the original contrast range remaining. Opposite page: The region of space around Rho Ophiuchi contains clouds of gas and reflection nebulae. Preserving details called for reducing the range of contrast, and the results are magnificent.

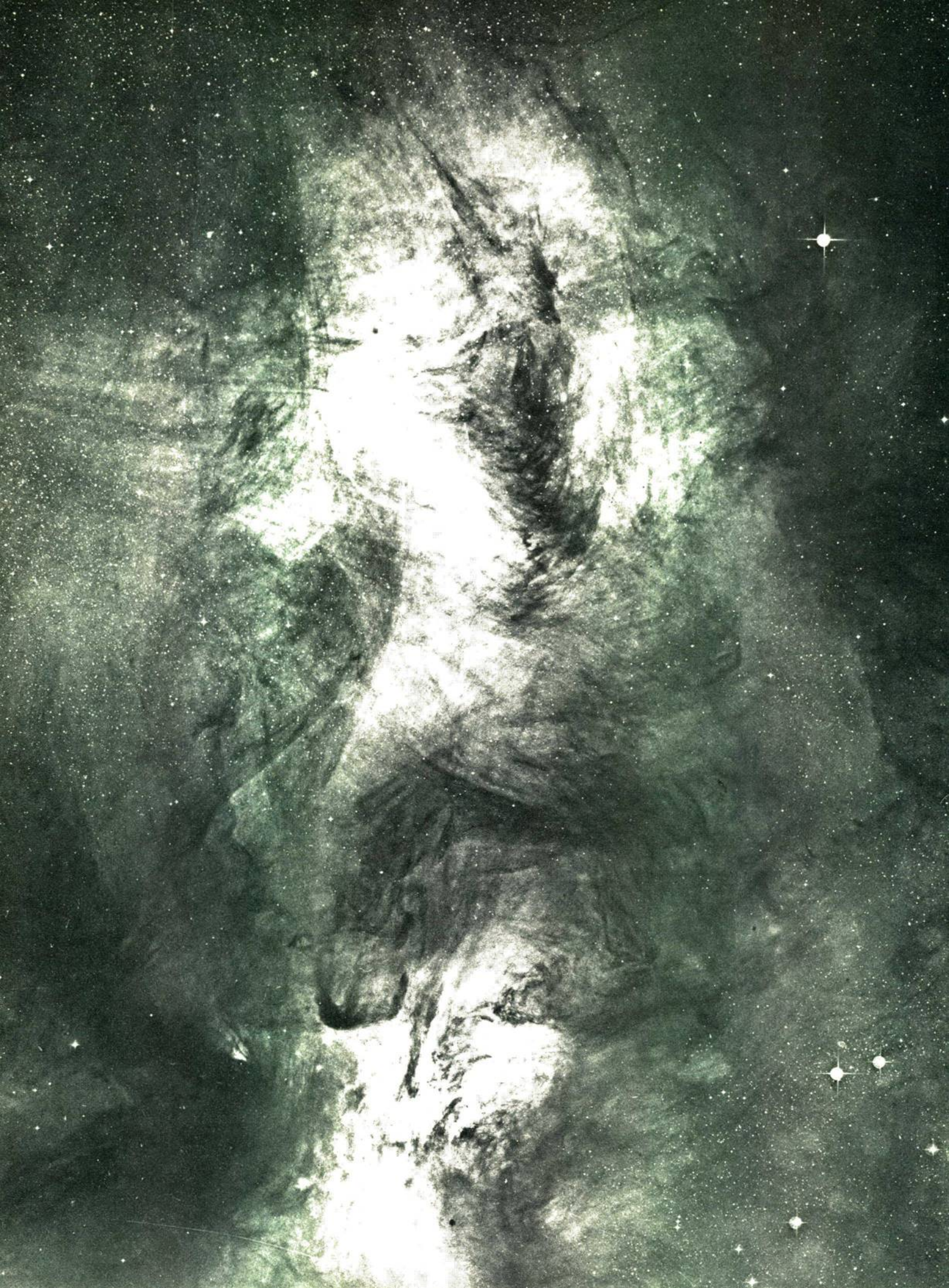
detail to be increased. Stars and small scale structures don't appear in the mask and are therefore unaffected by it.

An old plate taken on the 3.9 m Anglo-Australian telescope (page 18) features the beautiful southern galaxy M-83 (NGC-5236). The two photographs show the usefulness of the unsharp mask in revealing the intricate structure of the dust lanes and spiral arms. The burned-out print was made by direct enlargement from the original plate.

Embedded in swirling dust, the 4.6 magnitude star Rho (ρ) Ophiuchi (opposite) illuminates part of the gigantic Ophiuchus dark cloud. The peculiar crisscross structure, typical of reflection nebulosity, was captured on this IIIa-J plate made on the 1.2 m U.K. Schmidt telescope. The extreme complexity of the region is revealed by the masking technique which emphasizes the alignment of dust clouds in interstellar magnetic fields.

Both these techniques depend on having a variable-brightness diffuse-light contact copier. The equipment use at the Anglo-Australian Observatory, a modified Agfa-Gevaert SV400 unit, is designed to take plates up to 15" x 18" in size. For smaller originals, a simple contact copying frame with an efficient diffuser such as opal glass, illuminated by a ordinary light bulb in a large reflector, would work well. A domestic light dimmer, or better yet a calibrated variable transformer, should be used to achieve the wide range of illumination required, especially with the masking technique. 🐾

Currently Research Photographer at the 3.9 m Anglo-Australian Telescope, Dave Malin is working on problems of hypersensitization and extraction of maximum information from photographic plates. Apart from photography, his research interests include supernova remnants and the structure of radio galaxies.



ASTRONOMY forum

Eclipsing '79

The thing in California, of course, is to be casual about palm trees, to act as though you don't even notice them or to pretend that palm trees actually belong there. The thing is to believe that anything worthwhile is already in California and couldn't possibly be found in those awful "other" places people live. The thing is to work for an enormous aerospace industry where highly skilled and intelligent people bring home fat paychecks every week. Week after week bank accounts grow as spirits languish.

I work for one of those California space-age industries. I watch engineers peek over their shoulders to be sure that their cosmic secrets are safe from janitors and the general public. I listen to technical conversations which contain numbers and letters strung together in intricate sequences, which communicate principles as joyless as they are necessary, which are as devoid of feeling as is the solar wind.

And I conclude that *this* is what it is:

Either you allow the Sun and Moon to overwhelm you, or you don't.

6:15 a.m., February 23: The streets of Great Falls, Montana are wet. Cottonwood branches make stiff, rattling sounds and heaps of dirty snow are piled here and there beside driveways. We wonder, why was a town built here in the first place? Why would this town become the largest in the state? And then we see it: the Missouri River freeflowing even in midwinter, unexpectedly wide this close to its headwaters. The Lewis and Clark expedition reported, they say, the rumble of falls from miles away, but these waters rumble and tumble no more. There are dams now. Concrete bridges mark the places



Photo by John Cade.

where wagon trains once came to a dead halt. Reservoirs and irrigation ditches interrupt the Charles Russell landscape.

We stop for breakfast at a coffee shop, my two friends and I. The streets in the heart of town are amazingly quiet this Monday morning. "Don't be surprised," I tell my friends, "if the residents are less than enthusiastic about today's solar entertainment."

They are amused at the prospect. "That might be the most interesting response of all. 'Eclipse? What eclipse?'" We all laugh then.

The waitress delivers our breakfast, lots of food, especially potatoes. She stares at our clothes. "You folks from out of town?"

"We flew in last night from California," one of my friends says. "I used to live in Montana," I add.

"California! Really?" The waitress regards us doubtfully.

"Really."

"California." She pauses, a look of distant places in her eyes. "What are you guys doing here?"

"The eclipse," we say, trying to hold back the smiles. "We're here for the eclipse."

"You're putting me on. You came all the way from California to see the

eclipse? You're putting me on." Now *she* tries to look serious too.

"No, honestly. That's why we're here."

She disappears into the kitchen while we eat our breakfast. She returns repeatedly to refill our coffee cups and say, "You guys," giving us a conspiratorial wink each time. "You're not *really* from California. You guys. Really!"

7:30 a.m. Two hours remain before totality. A fifteen minute drive to reach the bluffs above the Missouri River, a location, we are told, from which we can view a vast chunk of central Montana and the last eclipse during this century.

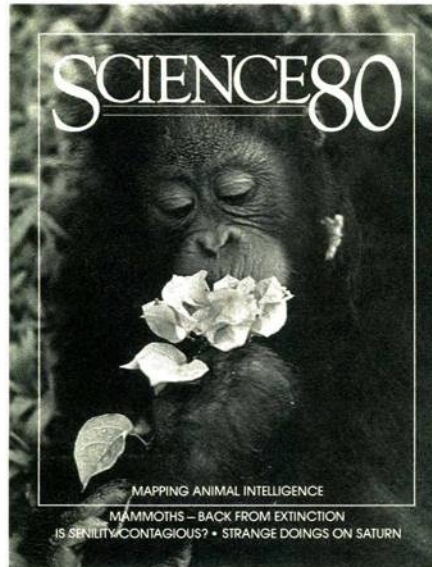
The route out of town carries us beyond the river and the airport into broken terrain, brown and arid, something out of the geologic past. We climb a steady grade for more than a mile and watch the country open wide. Now it begins to look like the Montana I know: windswept prairie stretching in all directions toward the snow-capped Rockies. Except for the semiconstant breeze, motionless: It has always looked this way and our spirits ascend with the ride.

"Is it my imagination or is it getting darker now?" I ask, turning on the car radio.

My friends reply that it's my imagination, but our excitement is building and I notice them craning their necks to get a better look at the sky. The radio announcer reports that the odds have improved and now are 50-50 for seeing the corona through broken cloud cover.

8:45 a.m. Fifty minutes before totality. We park the car off to one side of a dirt road. Below us Great Falls and the river. Occasionally, a pickup or passenger car drives slowly past, everyone looking for the perfect vantage point. As far as we are concerned, we have found it after 1600 miles. We are ready.

A BEAUTIFUL NEW SCIENCE MAGAZINE



FROM A RENOWNED SOURCE

Are bacteria winning out over wonder drugs? Is senility a communicable disease? What's the new code that even computers can't crack? Do black holes really exist—the most exotic of space objects?

How will electronic shopping work? Can biofeedback control blood pressure? What's the danger of "acid rain"? How are lasers replacing scalpels?

If you enjoy keeping up with all the changes taking place on worldwide frontiers of science . . . if you delight in adventure, challenge, and discovery . . . welcome to SCIENCE 80, the new bimonthly magazine from the American Association for the Advancement of Science, the largest general scientific organization in the nation. The new magazine about all the scientific disciplines—and you. Where you've been. Where you're at. Where you're headed. And why.

A Magazine for You— Not Just for Specialists

SCIENCE 80 is edited for you and your entire family. It's written by writers who not only know their science, but also how to make the most complex subjects easy to grasp and memorable.

You keep up with outer space. The inner workings of the mind. What's being done in medicine. New discoveries in chemistry, biology, physics, mathematics. New developments in natural history.

You meet the people who are making the headlines—as well as those who work behind the scenes in all the world's great laboratories, research centers, field stations. You visit the future for forecasts of tomorrow—and step back into history for a better understanding of the present.

Splendid Color Illustrations

You delight in some of the most vivid and informative illustrations you've ever encountered in any magazine. Full color photographic portfolios. Microscopic enlargements. Satellite overviews. Computer visualizations. Drawings, diagrams, charts. Reproductions of art and artifact. Few magazines are so breathtakingly illustrated. SCIENCE 80 is a magazine for re-reading many times! For sharing! For keeping—and creating a fine science library!

Available Only by Subscription

SCIENCE 80 is not sold on newsstands. It is available only by subscription. The regular price is \$12 a year. But when you become a Charter Subscriber, your price is only \$9. You save an immediate \$3 for an initial 25% off. And you get other Charter Benefits, too. Additional savings in the future—always the lowest possible price on all renewals and gifts. Plus our full refund guarantee!

Send No Money

"Science," observed Oliver Wendell Holmes, "is a first-

rate piece of furniture for a man's upper chamber if he has common sense on the ground floor." *Your* first floor is undoubtedly furnished very well. Now come fill in some of the nooks and crannies upstairs with SCIENCE 80.

Come learn what scientists the world over are researching, unearthing, theorizing. Come find out what's being invented—new products, new materials, new ways of doing things. Come see what they're discovering about you—your body, your mind. Come learn with SCIENCE 80 by reserving your Free Issue and Charter Subscription now!

CHARTER RESERVATION FORM

Please enter my Charter Subscription, bill me for only \$9 (instead of \$12), and put me down for all other Charter Benefits—additional savings in the future on all renewals and gifts, plus your full refund guarantee—if ever the magazine fails to live up to my expectations, I can cancel and get back every penny I've paid—even if it's my last issue.

MY NAME _____
Please print

ADDRESS _____

CITY _____ STATE _____ ZIP _____

Send no money. Just mail to Science 80.
1515 Massachusetts Avenue, N.W., Washington, D.C. 20005.
Allow at least 6-8 weeks for delivery of first bimonthly issue.

SCIENCE 80

American Association for the Advancement of Science
H9N24

Can you really see a wall of blackness zooming across the heavens during those few seconds before your eyes, the Moon, and the Sun reach alignment? Does it get dark, dark enough so that yard lights come on, truck drivers have to switch on their headlights and animals become confused? Do birds go to roost; do the cows bed down for a nap?

9:15 a.m. Eleven minutes to go. Now there are cars parked up and down the road, each at a respectable western distance from the next. There is a high school science class and a young instructor who checks to see that every student is using something to protect his eyes. People set up tripods and fidget with cameras. In the field before us is a shallow depression where collected snowmelt turned to fractured ice flashes a billion broken images of the crescent Sun nearly gone. The air is cold; we jump up and down to keep from going numb. A child keeps asking her mother, "When is it? When is it, Mommy?"

9:23 a.m. "Oh my God!" someone says. "Look. Look!"

We pivot around to face the west and see other people pointing. We point too. We point to the edge of the sky where, 100 miles distant, somewhere over the continental divide, a thin line of ink invades the morning light. Totality and the edge of a different world. We see it moving. Actually see it rushing toward us, supersonic, a wall of night. It is unbelievably quiet, mysterious, and unnatural. And just ahead of the black curtain, to the astonishment of us all is a sunset — confused reds, orange and yellows — streaking across the heavens from west to east.

The shadow rushes eastward, eroding the sky, abolishing the morning and with it, our powers of comprehension. "Look!" we keep urging each other, struggling to understand what is happening. And "Look!" again, for we know that we are witnessing a celestial event. We have no other word.

I feel dizzy, blink, and realize that my sense of orientation is disturbed. Then the lights do come on; Great Falls twinkles below us and the great river disappears in starlight. Unearthly illusions move between land and sky and we discover the ring of light around the dark side of the Moon. We are standing in the center of a place which is no longer our world. Nature has conspired to defeat our convenient ideas of reality so that space, time, and the laws of Dr. Einstein are overshadowed, too.

For a moment I am afraid. Fearful, as our naked forebears must have been fearful, that the Sun will not return. I recapitulate an ancient emotion that I cannot go back to a place where warmth and light are comfortable

companions. And then I see another kind of beauty in darkness and worry that, in returning, I will be unable to reconstruct the texture of this mood. I want to stamp into permanent store the design — the look, the feel, and above all, the silence — of this time.

And then the sudden reversal when dawn invades the west. The mountains glow faintly at first and then, at once, pure sunlight strikes the snow. We see the curtain pass and want to travel with it. Too brief: Something in us would linger with the night, would contemplate a more mysterious dimension which has visited and gone in less than three minutes.

Before we catch our plane, we decide to have a cup of coffee back in town. The waitress is taking down a dozen orders but she stops to exchange smiles and watch for what it is that we know. "Did you see it?" we ask her, wondering where we could begin. "Did you notice how quiet it was out there?"

"It was awfully busy in here," she

says, "but I got a chance to step outside for a second. It really got dark, didn't it?" And then she rushes away to deliver more hamburgers and potatoes.

This morning I drive past the palm trees to a sprawling plant where more efficient missiles are being designed. I remember how quiet it is in Montana. I am thinking how everyone is scared to death, and, if you have any sense at all, you are afraid each time that you discover something new. I think about the waitress in Great Falls, Montana who is forever pouring coffee and joking with the cattle ranchers. I am asked whether it was worth going all that way to watch one morning, briefly, turn to night and I think:

This is what it is. To allow the Sun and Moon to overwhelm you now and then.

Robert Kirvel
Pacifica, CA

Remember Viking?

To tell the truth, I was surprised Viking worked at all. At meetings during the pre-launch years, planetary scientists used to trade tales about the latest Viking disaster: problems with the computer, the experiments, or the launch vehicle. In 1975 I saw a Viking team friend carrying a collapsible umbrella that looked like a folding antenna. I accused him of carrying off some piece of Viking hardware. "No," he said, "it couldn't be from Viking. It works." My own estimate came to be that each Viking had only a 50-50 chance of making a landing.

The plan was for the Mars data to be transmitted and received by the Jet Propulsion Laboratory, nestled at the base of the mountains north of Pasadena on the edge of the Los Angeles sprawl. The days of the first Mars surface studies were so smoggy that you often couldn't see the mountains from three miles away. Dusty Mars was clearer than eye-stinging Los Angeles! It made you wonder about us presuming to establish our presence there.

On the night of July 19, we didn't

know if we'd see Mars or not. Many times before that night I had tried to visualize the planet, a fantasy that got honed down as more data came in over the years. That last night when we still didn't know what Mars looked like seemed a good time to try a prediction. What I wrote in my notebook was:

"I would predict site will be a dusty wasteland. Mostly windblown dust and gravel. A few but not many rocks. Perhaps no craters in evidence close by, but a few distant hills might be crater rims of 100-meter to half-kilometer craters. I'd predict no visible sign of life in pictures, primarily because of harsh Mars conditions (winds, temperature, dust, lack of water) and because of (memories of) my drive through dry Peruvian desert where no signs of life were visible for many miles...I'd predict some signs of wind action: shaped or eroded rocks, possible desert pavement, striations or dunes in dust...."

Not bad, but I should have opted for more rocks.

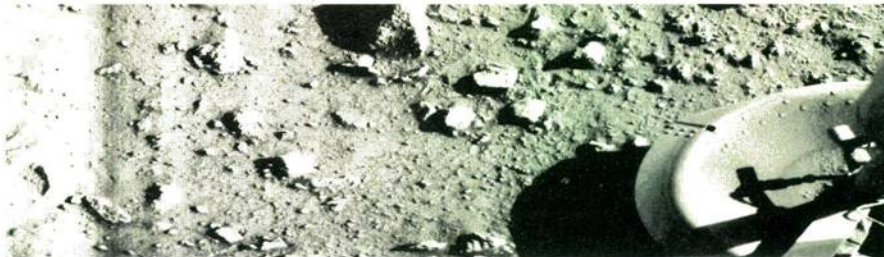
The landing was scheduled for 5:12 a.m. PDT. A 4:30 drive from downtown Pasadena to JPL revealed a deserted smoggy cityscape with steel-green trees discolored in the glow of fluorescent lights. The press center at Von Karman auditorium, by the JPL gate, was a hive of activity with CBS vans and their umbilical cords connected to the building. On one afternoon three weeks earlier, there had been less than a dozen newsmen writing — almost listlessly — about pre-landing orbiter discoveries. About 50 people came to a press conference on orbiter operations; about 80 came to a



conference on landing site selection. But on this day there were more than 200 people there. Newspeople were now rubbing elbows with a variety of guests, each with some claim to a pass that let them through the gate. There were editors of technical journals, science fiction writers, and what appeared to be space groupies. Television network reporters, such as NBC's Roy Neal, each occupied his own brilliantly lit corner with a carefully chosen backdrop of the Viking lander mockup or a recent Mars photo; assistants, like traffic cops, gently barred stragglers in the milling crowd from blundering into the middle of a live interview.

The largest cluster of onlookers with popping flash cameras surrounded not the Viking scientists, who took a few moments off work to pass through and be interviewed, but a spiritual father of space travel, Ray Bradbury. Ray reportedly had decided at the last minute *not* to wear his T-shirt that said, "Bradbury was Right!"

The auditorium was dotted with TV monitors that would show the first pictures. They now carried a running progress report from the best mission commentator in the business, JPL's "voice of Viking," Dr. Al Hibbs. The actual landing seemed to come upon us too fast. People were chatting amiably.



Already 5:06, the monitors were reporting that the lander was experiencing a heat pulse during atmospheric entry, but many people were still chatting. Breathless anticipation comes on you only at the beginnings of things; endings sneak up. There was no great hush as the lander neared the surface. People gathered in groups facing different monitors. 5:12 came. There was the word "touchdown" from the monitors, clearly heard. And cheering. Bradbury remarked to some writer friends, "I don't think a generation of writers has ever been so lucky."

Cheerful minutes sped by as preparations were made for the first pictures. More interviews in the bright lights.

By 5:53 Viking landing imaging team leader Dr. Tim Mutch in another JPL building was on the monitors looking relaxed, but facing a hectic 24 hours of picture receipt, interpretation

and press conferences. The first pictures of the martian surface were coming in, line by line.

At 5:55 voices among the 200 reporters in the room: "Rocks!" "Son of a bitch!" "It's Mars, folks!" On the TV monitor, Tim Mutch was practically immobilized by the astonishing clarity of the unfolding scene of barren soil: "I...I...just don't feel like talking," he said with a smile. Two minutes later he had regained his willingness to speak, and his voice came in snatches above the commotion in the auditorium: "...resolution is fantastic!...details are incredible!"

By 6:02 a scene of gravel had assembled itself. Someone behind me said, "Hell, that's just like my parking lot downtown."

By 6:18 the panoramic picture was unfolding on the screen. A girl said, "Oh, my God!" A distant hill was dotted with dark shapes. Somebody said, only half jesting, "Are those bushes up

S&S Optika, Ltd.

WORLD'S MOST USABLE STAR ATLAS



- 24-Page Full-Color Atlas of the Heavens
- 11"x14" Plastic Finished Card Stock
- Luminescent Star Finder on Front Cover
- Table of Planetary Locations \$7.75

VARIABLE FREQUENCY DRIVE CORRECTOR

- 25-Watt Output
- Solar, Lunar and Sidereal Presets
- Infinitely Adjustable Base Rate
- Instantaneous Add and Subtract Pulse Buttons
- Fully Grounded for Safety
- Includes 20" 12-Volt Car Cable
- 12-Volt DC or 115-Volt AC Operation
- Coil Cord Included
- Free Option: Straight Cord please specify length



\$114

MICRO-GUIDE

- Output-Frequency Continuously Variable from 50-70 Cycles
- 6 Watt Grounded Output Can Drive a Celestron 8
- NASA Spec Circuit Board
- 15' of Battery Cable



\$39

GUARANTEE

With your purchase of a Celestron from S & S Optika, we guarantee to test and proof your Celestron in our Optical Laboratory and perform the necessary adjustments to maximize its optical quality and minimize any mechanical operation problems that might occur. In addition, S & S Optika will furnish a letter of certification and a 200 Line Ronchigram proofing of the optical quality. Please write or call for prices.

NOTE: Freight via UPS no charge in continental U.S. only on all of the above orders.

S&S Optika, Ltd.
3855 S. Broadway
Englewood, CO 80110
Telephone (303) 789-1089



PACKAGE #7

EDMUND 2001 ASTROSCAN:

- Rich-field, low power, 4" Telescope
- Comes with a 28mm RKE Eyepiece (16x)
- Great for wide-field scanning of the Heavens. Milky-way views are breath-taking.
- Included with Package #7 is our 24 page Star Chart.

Total Price \$169.00

FREE! Send me FREE INFORMATION about S & S Optika Products. ☐ Dealers for Celestron, Edmund, Unitron, Meade & Pentax.



Here is my order for:

- ☐ Accessory Tray—\$20.00
- ☐ Accessory Case—\$14.00
- ☐ Latitude Adjuster—\$19.00
- ☐ 25 wt. VFO—\$114.00
- ☐ 6 wt. Micro-Guide—\$39.00
- ☐ Star Atlas—\$7.75
- ☐ Package #7—\$169.00

Include check, money order or Master Charge or Visa Acct # with your order. Colorado Residents include 3% sales tax.

Send me the above illustrated 32 page Celestron Color Catalog—\$2.00. ☐

Name

Address

City State Zip

Telephone & Area Code () Dept. A

there in the distance?" They weren't.

Who would believe that this was television from Mars, like the Olympics from Montreal? JPL spokesmen said that these live pictures from Mars were actually better than the test images they had generated in the lander mockup in the room next to the auditorium. That mockup, used as a press display, had an imaginary rugged martian scene painted long before by the landing artist Don Davis. Scientists used to come and look and scoff knowingly in hushed tones. "He's got too many rocks, you know." As the real martian rubble unfolded before us, Davis' work was beginning to look better and better.

By 6:37 Tim Mutch was back, commenting, "You just wish you could be walking out across that terrain. That's the only thing I kind of regret."

By 6:42 people were drifting away, marveling. Perhaps only 100 were left in the auditorium.

July 20, 1976 ticked away. The President himself noted the astonishing fact that the first successful instrument landing on Mars came seven years to the day after the first footsteps on the Moon. "The space programs," he said in a White House news release, "...reflect...our unrelenting spirit of adventure." He proclaimed July 20, 1976 as Space Exploration Day, urging us "to observe this day with appropriate ceremonies and activities." In JPL there was a rush to carry out orders. Champagne was reported in the mission control buildings. One wondered if anyone outside JPL — all those cars rushing to wherever they go on the L.A. freeways — cared. Somehow you had this peculiar thought that the city ought to look different on the day the first pictures came in from Mars.

First press release prints came by midday. The panorama print was not as sharp as one might have hoped, but enthusiastic newsmen grabbed it up. And it was soon in the papers. A few hours later, an improved computer processing had produced a better print, but most papers had already run the first one because it was *first*. The second version, with sharper rocks and a more evenly shaded sky, was not *news*. The *L.A. Times* ran the second print the next day, but most readers of most papers didn't get to see it. But the reporters had no lack of enthusiasm: as someone muttered in the back of the room, "When you get a bunch of hard-bitten reporters applauding you, you've really done something."

The news conference was strange in other ways. After months of voyaging to the unknown world of Mars, where the fantastic Martians of H.G. Wells, Edgar Rice Burroughs, and Ray Bradbury lived, there was more discussion of those ordinary brown

rocks than of the missing Martians. There were credits to the people who had made it possible — the American people, as NASA official Noel Hinners said. He said this was "the American way of doing things: going out...exploring." Another person chatting in the back of the room remarked that "this is what exploration's all about. You fly in blind and then look around and see what's there." James Martin added that many of the engineers who had built the machinery might be "laid off" by now; the work was done several

years ago. He hoped they wouldn't be forgotten.

July 20, 1976 — first day on Mars — slipped away. What was it all for? One of the Viking officials in the press conference had quoted Norman Cousins, the brilliant editor of *Saturday Review*, to the effect that "Progress is what is left over when humanity confronts an impossible situation." Once everybody had known it was impossible to fly to Mars.

William K. Hartmann
Planetary Science Institute

Stephen W. Hawking

Perhaps the most prestigious theorist currently studying black holes and their characteristics is Stephen W. Hawking of Cambridge University in England. Professor Hawking, only 37 years old, is the brilliant leader of a team of astrophysicists at Cambridge who are investigating the particles and radiations which emanate from black holes. By the age of 30 he had already attained a leading position as an authority on gravitational physics.

When the achievements of the physicists of the 20th century come to be considered objectively, the work of Stephen Hawking will be writ large in the annals of science. His advances have paralleled those of the greatest physicists of the past. He has taken a step as great as that of Michael Faraday who linked electricity and magnetism, or Einstein who found a relationship between energy and mass. In short, Hawking has shown how the world of microphysics, governed by the laws of quantum theory, is related to the large scale structure of our universe, governed by the theory of gravitation.

Although the basic concept of black holes can be traced back to 1796, it wasn't until Einstein's general theory of relativity was applied to stellar evolution that interesting results began to appear.

A star is a fiery ball of matter held together by the gravitational forces between all its particles. Since gravity is always an attractive force, a star can exist only if it has some means of supporting the weight of its layers against the inward crush of gravitation. In a star like the Sun, this necessary outward pressure is provided through the heating of the interior by nuclear fusion reaction. But what happens when a star reaches the end of its life and no longer has a nuclear reactor? Unless some new source of pressure can be found as the internal fires cool, the star must inevitably contract indefinitely.

In the case of dying stars of low

mass, the gravitational collapse is finally balanced at a diameter of about 1200 miles by the pressure of electrons. Some exhausted stars are too large to be held up by this electron pressure and these objects collapse down even more. As the electron pressure is overcome and the electrons are forced into combination with protons, the result is an object composed only of neutrons: a *neutron star*, held up by the pressure of neutrons.

These giant balls of neutrons, only 6 miles across, were discovered in 1967 as the flashing pulsars. But an object which has a mass more than twice that of the Sun cannot settle down to become a stable neutron star. Even the pressure exerted by neutrons is incapable of halting the collapse, and science knows of no force stronger than neutron pressure to prevent further collapse.

The inevitable result is that stellar objects of more than about two solar masses must collapse down to a single infinitesimal point. Higher mass stars may perhaps shed some of their excess material in an explosion, but the basic conclusion is still unaltered: a massive defunct star must leave a core which will plunge into itself indefinitely. According to Einstein's general theory of relativity, the collapse will proceed right down to a *singularity* at which the radius of the star becomes zero and the gravitational force infinite.

Before that singular state is reached, however, the star has already shut itself out from our universe and therefore from our measuring instruments. At some stage in its inward plunge the star shrinks through that radius at which the escape velocity exceeds the speed of light. Once the matter has vanished inside this zone, known as the *event horizon*, we can no longer see it even in principle — it is totally prevented from sending out any kind of signal or information at all. The Princeton physicist John A. Wheeler coined the term *black hole* to describe such a cosmic vanishing point.

In 1971 Hawking proposed an

STAR LINER

Manufacturers of Fine Yoke Design and German Equatorial Telescopes Since 1952

Complete Star-Liner Telescopes

Completely hand-machined instruments featuring the finest optics throughout—all mirrors are pyrex, hand-figures to 1/20 wave. All units are completely guaranteed for 1 year. Delivery within 90 days.

- 6" F8 Econo-line 1½" shafts...\$390
with clock drive,
setting circles...\$540
- 8" F7 Econo-line 1½" shafts...\$495
with clock drive,
setting circles...\$640
- 8" F7 with Star-Liner mount,
1-3/4" shafts...\$640
with clock drive, setting
circles and more...\$899
- 10" F6.5 with Star-Liner mount,
1-3/4" shafts...\$930
with clock drive, setting
circles and more...\$1250
- 12" with Star-Liner mount,
clock drive, setting circles,
much more...\$1595
- 14" with Star-Liner mount,
clock drive, setting circles,
much more...\$2650

THE STAR-LINER MOUNT

Compare these features with any other mount on the market. Two years in development, this equatorial mounting is unexcelled in performance.

- Designed for stability and beauty. Cast aluminum, carries 6" to 14" telescopes.
- Steel shafts, cadmium-plated, 1.75" diameter (2.00" on 12.5", 14"). Manual and electrical slow-motion controls available.
- Polar adjustments are precise and easy with a fine-aligning device.
- Entire mount rotates 360° for quick, easy alignment on local meridian.
- Fully rotating tube, with interchangeable cradles, permits you to switch to larger aperture without buying a new mount.



For complete catalog send \$1 U.S. to (overseas mail \$2)



1106 S. Columbus Blvd.
(DEPT. 2-S)
Tucson, AZ 85711
602-795-3361



INDIA

A Scientific/Cultural Expedition To Six Cities And A Specially Selected Site On The Center Line of The Path-Of-Totality

by special arrangement with the Division of Continuing Education

COLUMBIA UNIVERSITY

Faculty members will accompany the Expedition as lecturers on the scientific aspects of the trip, and on the history and culture of India. Highlights will also include talks by members of India's professional astronomical community, visits to ancient and modern observatories, as well as many of India's historical and cultural sites.

A Two Week Deluxe Tour Including:

- Jet Travel Via Air India • Deluxe 5 Star Hotels • Guided Sightseeing Trips • Sumptuous Breakfast And Dinner Daily • Special Welcome To India Gala • Eclipse '80 Celebration Banquet • All Transfers, Taxes, Tips, & Portage • Travel Within India By Scheduled Jet And Deluxe Private Motor Coaches.

Only \$1595.* per person,
plus Columbia University Seminar Fee: \$50.

Space Availability Is Limited, Reserve Early For
This Unique Expedition . . .

Organized by: **St. Clair, Rothschild & Co., Ltd.**
Travel Arrangements by: **Lido Tours, Inc.**

*per person based on double occupancy, single supplement available, price quoted subject to airline rate increases, fuel surcharges and foreign exchange rate fluctuations.

4 FEB, thru
18 FEB, 1980



COLUMBIA UNIVERSITY FACULTY

Dr. Lloyd Motz, Professor Emeritus of Astronomy
Dr. Kevin T. Prendergast, Professor of Astronomy
Dr. Edward A. Spiegel, Professor of Astronomy
Dr. Barbara S. Miller, Professor of Oriental Studies

To: **ST. CLAIR, ROTHSCHILD & CO., LTD.**
SUITE 100, 199 MERRICK ROAD
LYNBROOK, NEW YORK 11563 516/432-1421

From:

Name

Number

Street

Apt #

City

State

Zip

Telephone: Home: ()

Business: ()

☐ Yes, I (We) will be joining you on this Expedition to India for Eclipse '80. Please confirm my (our) reservation.

☐ Not yet sure, please forward additional information on your Expedition to India for Eclipse '80.

Make Checks Payable to "Eclipse '80"

Deposit Per Person: x \$200.

Please list Names and Addresses of all additional travelers on a separate sheet and mail with this coupon.

Number Of Travelers: _____

Check Enclosed: \$ _____

Photo Courtesy of The American Museum of Natural History

entirely novel way to generate black holes. Rather than dealing with the wreckage from stellar decay, he outlined mechanisms which could lead to the formation of very small black holes. According to his research, conditions may have been right in the early history of the universe to make such tiny black holes. About 15 billion years ago, shortly after the Big Bang, the universe was very much denser than it is today. Under these conditions, enormous pressures may have squeezed matter into concentrations sufficiently great to form mini-black-holes. These black holes formed at the beginning of time and space are known as *primordial black holes*. (A typical primordial black hole might perhaps have a mass of a billion tons and a radius of 10^{-15} meters.)

What has excited physicists most about Hawking's work is the immense stroke of genius which led him to discover that a black hole in fact is *not* entirely cut off from our own universe after all. Hawking made the quite astonishing finding that a black hole evaporates like a hot body. This wasting process happens slowly at first, but then it gathers speed until the black hole finally detonates in a violent explosive release of energy in the form of particles and radiation.

Hawking was studying the question of what would be the quantum characteristics of the space near a black hole. To his surprise, the equations indicated that energy would be flowing out from the event horizon! One way of interpreting the equations is by the quantum process known as *tunneling*.

In tunneling, a particle which otherwise would not have sufficient energy to cross an energy barrier can still escape from confinement by tunneling through the barrier instead of having to go over it.

The tunnel exists because, according to quantum theory, particles in a sense never know exactly where they are — there is only a certain probability, never a determined certainty, that a particular particle will be found in any particular place. Therefore, a particle occasionally can stray beyond the event horizon of a black hole in a quantum jump without realising it — and without having sufficient energy (which isn't possible anyway) to cross the barrier.

This tunneling process in the region of a black hole, Hawking found, becomes easier and more common the smaller the black hole is. In other words, the effective temperature determined by the radiation emitted from the black hole increases as the black hole shrinks. So the evaporation of particles from a black hole slowly gathers momentum. Eventually a final stage is reached when the rate of

evaporation rises quickly to a maximum and the black hole bursts into our universe in a tenth of a second.

An amount of energy equal to 1/100th of the Sun's luminosity jumps out of the space-time fabric from a volume billions of times smaller than an atom. Martin Rees of Cambridge has suggested that this extraordinary phenomenon could be detected by searching for radio pulses emitted by the charged particles flung out into space by the explosion. To date, however, such explosive radiation has not been detected.

Hawking continues his search for a quantum theory of gravitation, a goal which, when once achieved, will make possible a final unification of all the theories of the fundamental forces in the universe. If his search is successful, his place in the history of man's attempt to comprehend the structure and workings of the universe will become even greater than it already is, and his name will become as well known as those of Newton and Einstein.

Simon Mitton
Cambridge University

Galactic Orbit of Pioneer 10

Pioneer 10 is the first manmade object to escape from the solar system. It was launched from Cape Canaveral on March 3, 1972 on a trajectory to Jupiter. Twenty-one months later it made its close flyby of the giant planet. During the encounter, Pioneer 10 gained extra orbital energy away from the Sun by means of the "gravitational slingshot" effect. This effect occurs when a spacecraft falls into the gravitational field of a moving planet. Pioneer 10 is now in an escape orbit from the solar system and will eventually move into its own independent orbit around our Galaxy.

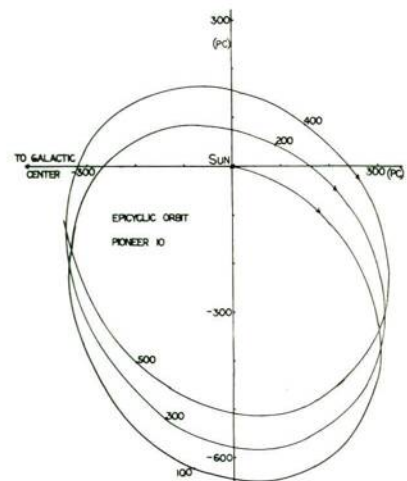
In a few hundred years it will be moving very nearly in a straight line away from the Sun, at an almost constant velocity of about 11.6 km/sec, or approximately 2.44 astronomical units (AUs) per year. The motion of the spacecraft will be dominated by the gravitational field of the Sun until it reaches a distance of about 1.5 parsec (309,400 AUs) 126,000 years from now. After this time it will be dominated by the gravitational field of the Galaxy and by the fields of the stars it passes.

While under the influence of the Sun, Pioneer 10's direction of motion is toward a point in the sky close to the present position of the star Alnath (β Tauri). Of course, Pioneer 10 will not get anywhere near this star because in the millions of years required to reach its position, Alnath will have moved away. The chances of Pioneer 10 coming within 10,000 AUs of any star in the next one billion years are negligible. Its direction into the constellation Taurus is almost directly opposite from the position of the center or nucleus of our Galaxy.

We ran an orbit for it on a Univac 1110 at the University of Alabama. The initial position and velocity coordinates of the spacecraft were supplied by J.D. Anderson of the Jet Propulsion Laboratory. The galactic-mass model used was one constructed by K.A. Innanen of York University, Toronto. These mathematical models

mimic the distribution of different populations of objects (such as young stars, old disk stars, and halo stars) and their velocity characteristics. In the model used, the Sun's distance from the galactic center was 10 kpc, and the velocity of a circular galactic orbit at this distance is 252 km/sec. These values have an uncertainty of about $\pm 10\%$.

In the computation of Pioneer 10's orbit we allowed for the fact that the Sun's galactic orbit is not circular. For example, the component of the Sun's velocity toward the galactic nucleus is 9 km/sec. This cancels out some of Pioneer 10's 11.6 km/sec velocity in the anti-center direction.



The diagram shows the motion of the spacecraft 528 million years into the future relative to a coordinate system centered on the Sun and keeping one axis always pointed toward the galactic center. This is called an "epicyclic" orbit.

You can see that in the next 500 million years Pioneer 10's furthest excursion from the Sun will be about 700 pc and its average distance from the Sun will be about 400 pc.

D.W. Keenan
Univ. of Alabama

Is your work at the cutting edge of imagination? Then Rolex wants to help you change the world.

The five Rolex Awards for Enterprise, in the sum of 50,000 Swiss francs each, are conferred to provide financial help for projects which seek to break new ground in their particular sphere, and which capture the spirit of enterprise shown by Rolex and Rolex owners.

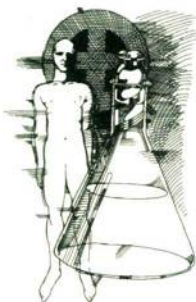
The kind of enterprise that takes a man like Julian Nott to world record-breaking altitudes in hot-air balloons, Sir Edmund Hillary to the top of Everest. Or Dr. Bill Lasley, a previous Awards for Enterprise winner, into new methods for saving and breeding rare species of birds.

These people epitomize the spirit of enterprise. The 1981 Rolex Awards for Enterprise seek others like them whose proposals for projects fall into any of three general categories:

Applied Sciences and Invention. Projects involving a step forward in research, experimentation, or application in the general field of science and technology.

Exploration and Discovery.

Projects involving exploration or discovery will be concerned primarily with venturesome undertakings or expeditions, and should seek to inspire our imagination, or expand our knowledge of the world in which we live.



The Environment. Projects in this category will be concerned primarily with our environment, and should seek to protect and preserve, or to improve, the world around us.

In addition to the 50,000 Swiss francs, each of the five winners will receive a specially inscribed Rolex Chronometer.

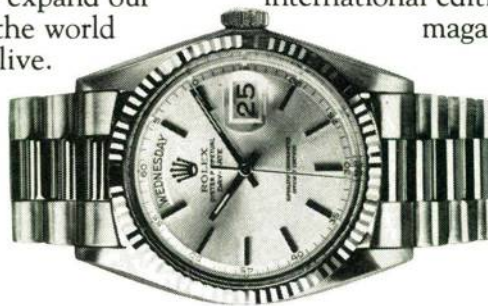
For an Official Application Form with detailed rules and conditions write to:

*The Secretariat, The Rolex Awards for Enterprise,
P. O. Box 178, Dept. 307,
1211 Geneva 26, Switzerland.*

Send your name and address and state the general nature of the project you are considering.

Entries must then be submitted in English on the Official Application Form and reach the Secretariat before April 30th, 1980.

The Rolex Awards for Enterprise selection process is exacting and arduous. Winners will be notified in December 1980, and their names will be published in the international editions of *Time* and *Newsweek* magazines in May 1981.



The Rolex Oyster Perpetual Day-Date Chronometer

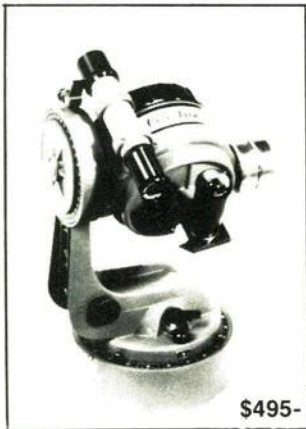

ROLEX

Celestron 90

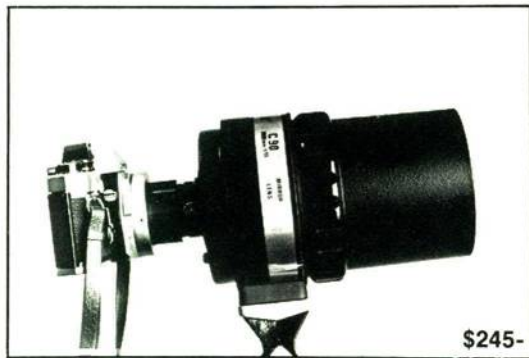
Available For Christmas



\$295-



\$495-



\$245-

**FOR THE PHOTOGRAPHER: BEGINNING ASTRONOMER:
FOR THE HOME WITH A VIEW: FOR THE NATURALIST:**

The C90 is unusually small and lightweight for its focal length (1000mm). This — coupled with its unusually-low price and high quality — makes the C90 Astro Telescope extremely desirable as a telephoto lens or spotting scope too. Accordingly, we've designed a complete product line around the C90 optical system.

The heart of the C90 series is the 90mm aperture, f/11, Maksutov-Cassegrain optical system, which is identical on all three C90 versions. As a result, the C90 is a telescope that's also a telephoto or a telephoto that's also a telescope.

The C90 Astro Telescope is supplied with advanced features usually found only on larger, more expensive telescopes — features like star locating setting circles, an automatic tracking system and slow-motion controls on both axes — that make using the telescope easy and convenient.

ACCESSORIES

Large Accessory Ring — C90 (LAR-C90) Simply thread the Large Accessory Ring (LAR) on the rear cell of your C90 and you will greatly enhance the versatility and potential of your instrument. The LAR, itself, has external threads that are the same as the rear cell of the C5, C8, and the C14 reducing plate. You can now use, on the C90, virtually all the accessories that Celestron has created for its larger telescopes to comprise the largest system of visual and photographic aids ever offered to the amateur astronomical community. **Price \$20.00**



Large Accessory Ring — C90 threaded on the C90 instrument



After Threading the LAR — C90 onto the telescope, the RFA is shown attached.

The RFA — You can have a wide-field telescope when you attach an RFA to your C90. The RFA will convert the C90 into a f/5.5 telescope with 25 power (with the RFA's standard 20mm Erfle ocular) with a field-of-view of over 2°. In such a configuration the C90 will offer spectacular wide-field views of such objects as the star clouds of the Milky Way and extended objects such as the Andromeda Galaxy; perfect for comet hunting!

SEE YOUR AUTHORIZED DEALER OR WRITE TO:

Celestron International

2835 Columbia St. • Torrance, California 90503 • U.S.A.
Telephone (213) 328-9560

Celestron® Binoculars

**New
Lower
Price**



**Just In
Time For
Christmas**

*
Order
Direct
or
Through
an
Authorized
Dealer

The name Celestron is synonymous with the finest, highest quality, high resolution astronomical optical systems. In keeping with this reputation, we established binocular specifications far above those of the popularly offered, department-store-variety binoculars. To meet our standards for true astronomical image quality, the images must be crisp and free of color distortion. The optics must be anti-reflection coated for maximum light transmission and contrast. For maximum image brightness, the exit pupil of the binocular must closely match the size of the observer's dark-adapted eye pupil. Finally, the binoculars must be precisely collimated to eliminate double images and avoid eye strain and other visual discomfort. Celestron binoculars are collimated at the time of manufacture and then again just prior to shipment on the precision laser collimator at our factory.

Binocular Specifications

	7x35	7x50	11x80
Magnification	7x	7x	11x
Objective Diameter	35mm	50mm	80mm
Angular Field	11°	7.5°	4.5°
Linear Field (at 1000 yds.)	576 ft.	393 ft.	235 ft.
Near Focus (approx.)	13 ft.	19 ft.	30 ft.
Interpupillary Range	52-78mm	52-78mm	52-75mm
Exit Pupil	5.0mm	7.1mm	7.3mm
Relative Brightness	25.0	51.0	52.9
Twilight Factor	15.7	18.7	29.7
Relative Light Efficiency	41.3	84.2	79.4
Height	5¼"	7"	11¾"
Weight	2.2 lbs.	2.6 lbs.	5.0 lbs.

Please send me the binoculars checked below. I have enclosed my check in the full amount. (Calif. Residents include 6% tax)

Qty:

☐ 11 x 80

☐ 7 x 50

☐ 7 x 35

NAME _____

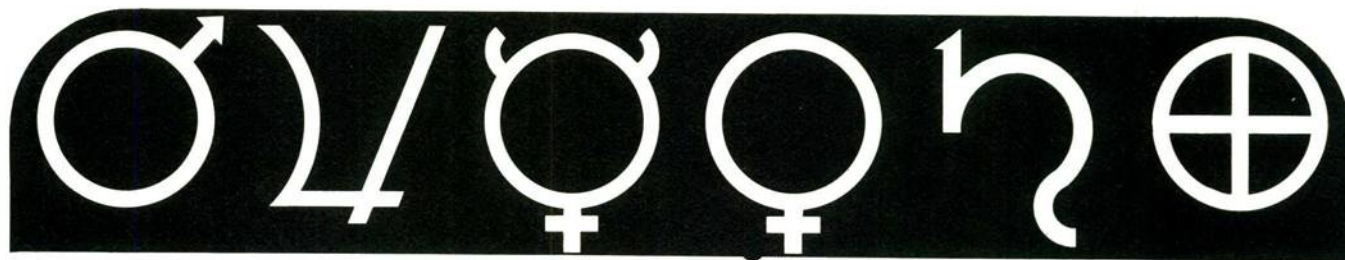
ADDRESS _____

_____ ZIP _____

Celestron International

2835 Columbia Street • Box 3578 • Torrance, CA 90504

Phone (213) 328-9560



SKY ALMANAC

Look Out for the Leonids

December Previews

- 3 Full moon
- 4 Mercury 4° north of Uranus
- 7 Mercury at greatest elongation west
- 10 Moon 2° south of Mars
- 11 Moon-Jupiter conjunction
- 12 Last quarter moon
- 12 Moon-Saturn conjunction
- 13 Mars 2° north of Jupiter
- 14 Geminid meteors
- 17 Moon 4° north of Mercury
- 19 New moon
- 21 Moon 5° north of Venus
- 22 Winter Solstice
- 26 First quarter moon
- 30 Occultation of Aldebaran

As a glance over the previews will tell you, there are a lot of upcoming conjunctions. The prettiest will likely be those involving the Moon, Mars, Jupiter, and Saturn. The three planets are well up in the sky and are bright.

With the arrival of November, the pretending is over: winter is just around the corner! When Orion begins rising as early as 9 or 10 o'clock, you can't help feeling a quickening of interest as this old friend and all his companions of the winter skies reappear from their summer "hibernation."

Though the planets never show any such seasonal association, their visibility is "seasonal" too, in that it's affected by whether the part of the ecliptic they're on lies north or south of the celestial equator. This in part explains why Venus and Mercury have been hard to see recently. Mars, Jupiter, and Saturn on the other hand are all in the general area of Leo, and here the ecliptic is well north of the celestial equator, so all three are easily visible.

Step out now and take in the skyshow; here's your chance to see the winter constellations without enduring the blasts of winter's cold.

Mercury

Little will be seen of Mercury this month, for the small planet passed its point of maximum elongation (separation) from the Sun late in October and

is now moving rapidly towards inferior conjunction on the 20th of November, when it'll lie between Earth and Sun.

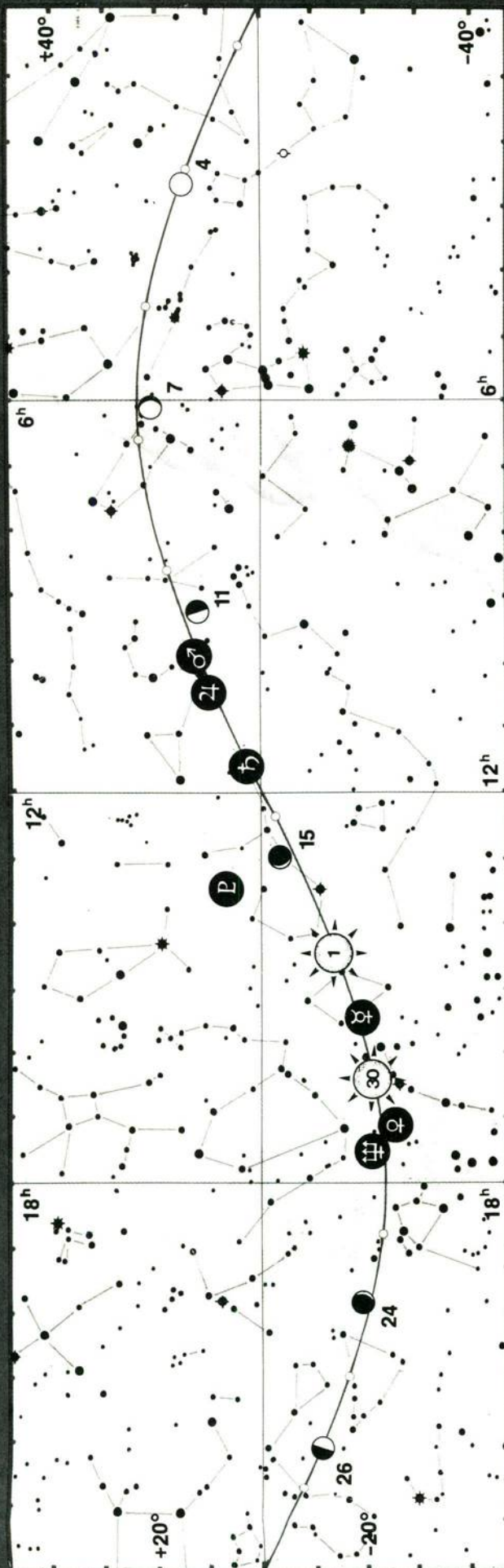
On the 8th of November, however, Mercury will be about 2° south of Venus in the evening sky. Both planets will be very low (less than 5° above the horizon half an hour after sunset), so you'll need an observing site with a low southwestern horizon. Mercury's crescent-shaped disk, 8.1 seconds of arc in size and 37% lit, will be at magnitude +0.5; Venus, at magnitude -3.3, will appear gibbous and its 10.6 arc second disk will be 95% lit (see Planet Finder). To locate the two planets most easily, use binoculars or a telescope with low power and sweep just above the horizon.

Venus

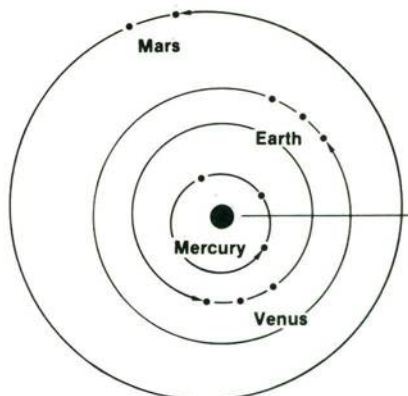
Venus remains low on the western horizon at sunset for much of the

Most of Mare Serenitatis and the eastern half of Mare Imbrium show well under local morning light. (See Gazer's Gazette this month for more about the Moon.) Film was Tri-X with an 8" f/10 Newtonian, exposure 1/5 second using eyepiece projection. Richard Berry photo.



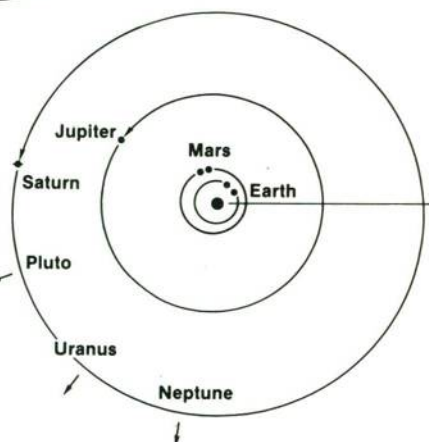


The Planets in Their Courses



The positions of Mercury, Venus, Earth, and Mars in their orbits are shown for the beginning, middle, and end of the month. (Mars for the beginning and end only.) The vernal equinox is the line at right.

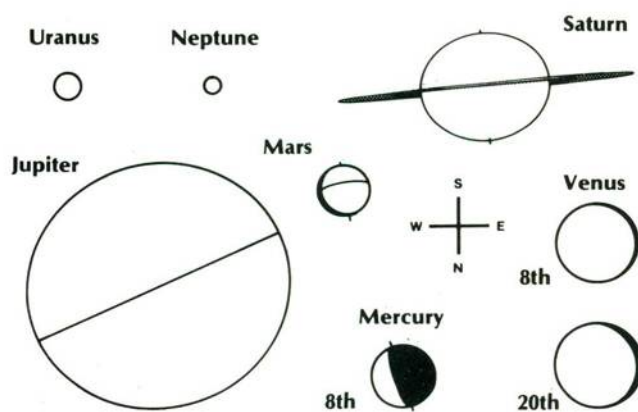
The orbits of Earth, Mars, Jupiter and Saturn are shown at right. Earth and Mars' positions are for the first and last of the month; Jupiter and Saturn for midmonth. The outermost planets' directions are indicated.



Positional Data

Planet	Date	R.A. (1979.9)	Dec.	Mag.	Distance (AU)	
					from Earth	from Sun
Mercury	♂ 10	16 ^h 13.8 ^m	-22°00.8'	+1.0	0.79	0.35
	20	15 ^h 41.4 ^m	-19°10.0'	+2.4	0.68	0.31
	30	15 ^h 11.8 ^m	-15°11.3'	+0.8	0.82	0.32
Venus	♀ 10	16 ^h 19.7 ^m	-21°55.9'	-3.3	1.56	0.73
	30	18 ^h 07.7 ^m	-24°41.1'	-3.3	1.50	0.73
Mars	♂ 15	10 ^h 02.4 ^m	14°01.9'	+1.0	1.38	1.62
Jupiter	♃ 15	10 ^h 38.6 ^m	9°34.5'	-1.6	5.55	5.37
Saturn	♄ 15	11 ^h 43.3 ^m	3°56.5'	+1.3	9.90	9.40
Uranus	♅ 15	15 ^h 15.9 ^m	-17°49.5'	+6.0	19.71	18.72
Neptune	♆ 15	17 ^h 13.4 ^m	-21°39.4'	+7.9	31.16	30.28
Pluto	♇ 15	13 ^h 38.9 ^m	7°38.9'	+14.0	30.99	30.20

Telescope View





NGC-1499 (the California Nebula) is a swath of ionized hydrogen, made to glow by a young, hot star nearby, possibly Xi (ξ) Persei. Patrick McGuire used an 8" Schmidt camera and 160 ASA slide film for 20 minutes.

month, reaching an elevation at dusk of only 8° by month-end. Finding and following Venus during November and December will show you very graphically how close the match between Venus' and Earth's respective orbital velocities is: the planet can overtake us only very slowly, thus making venusian appearances very long and drawn out.

Moon

The Moon, two days past full, will pass through the Hyades Cluster and occult the first magnitude star Aldebaran on the night of November 5-6. The late evening event will be visible from all of the continental U.S. (except the northwest part of Oregon and most of Washington) and in Canada from the prairie provinces eastward.

The occultation happens starting around 04:00 UT in the southwestern U.S., and around 05:00 UT for the eastern parts of the country. Since the occultation happens after full moon, the disappearance is on the bright edge of the Moon, and you'll need a

telescope to follow the star right up to the instant it blinks out.

When the Moon rises as seen from where you live, locate Aldebaran in relation to it. Remembering that the Moon moves through its own diameter in about an hour, you can judge how late in the evening the event will happen for you.

Mars

Mars this month shows how rapidly a planet can scoot along past the background stars. On the 17th, the red planet will pass just a degree and a half north of Regulus, the bright star in the forepaw of the constellation Leo, spending about half of November on either side of the star.

During this month, the planet rises about midnight and will become easy to see in the east by 2:00 a.m. Take a look from night to night and follow Mars' progress as it seemingly chases Jupiter through Leo. (Some easy piggyback astrophotography will provide you with a series of shots to make a fine permanent record.)

The telescope owner by now should be thinking about the coming opposition (February 25, 1980); Mars currently is about twice the size it was when farthest from us back in January and it's about half the size it'll reach at opposition, when it'll be at its closest for this appearance.

Already apparent and becoming more distinct are the surface markings that were long thought to be topographic features. Mariner 9 and the Vikings overturned this notion, but monitoring the changing visibility of the dark shapes tells you about the clarity of the martian atmosphere and makes for enjoyable study.

Jupiter

One of the nicest aspects of watching Jupiter is that no matter what equipment you use — eyeball to 200" telescope — you get a satisfying view of something. Now everyone knows that a telescope reveals a lot, as do even binoculars, but just how does the naked-eye observer benefit? Lost to him are the glories of the cloud belts, the busy and intricate shuttlings of the moons. What's in it for him?

To the naked eye, it seems at first like all you get are the various transitory conjunctions (however spectacular) with this star or that cluster as the planet paces slowly through the constellations. But there's something more subtle and compelling than this: think back over the last jovian year. What were you doing when Jupiter was last in Leo? Or Capricornus? What events happened in your life while Jove strode in stately fashion through Taurus, past the



Above: Rick Schmidt photographed this Perseid meteor, one of about 60 observed over 2 hours. He used 400 ASA slide film, pushed to 800 ASA, with a 35 mm lens and a 12 minute exposure. Right: Rev. Ronald Royer shot the eclipsed Moon from California September 6 with a 4" f/5 astrograph, using 64 ASA slide film and a one minute exposure. The background stars are those of Pisces and Aquarius.

November Satellites of Jupiter				12:00 UT			
1	3204	• • ● •		16	3024	• ● • •	
2	31042	• • ● •		17	30214	• ● • •	
3	34021	• • ● •		18	2104	• • ● •	
4	42103	• • • ● •		19	0413	• • ● •	
5	40213	• • • ● •		20	41023	• • ● • •	
6	41023	• • • ● •		21	42013	• • • ● •	
7	42031	• • • ● •		22	42310	• • • ● •	
8	43210	• • • ● •		23	43012	• • • ● •	
9	43102	• • • ● •		24	4302	• • • ● •	
10	34021	• • • ● •		25	42130	• • • ● •	
11	21034	• • • ● •		26	42013	• • • ● •	
12	0134	• • • ● •		27	14023	• • • ● •	
13	10234	• • • ● •		28	20413	• • • ● •	
14	20134	• • • ● •		29	21304	• • • ● •	
15	23104	• • • ● •		30	30214	• • • ● •	
Jupiter = 0, Io = 1, Europa = 2, Ganymede = 3, Callisto = 4 (South is at top, matching the view in a telescope.)							

Pleiades and Hyades? When it traversed the star-clutter of the southern Milky Way?

Jupiter's course somehow provokes reflections like these better than any other planet's. Its 12 year orbit and ponderous progression around the ecliptic tend to remind you of an immense clock, ticking out the passage of time and events. Sentimental fantasy? Perhaps. But when you find you've been following its path even casually for several years, and you begin to connect the events of your life with the planet's place in the heavens, the idea may no longer seem so strange to you.

Saturn

Saturn is in the morning sky, having reappeared out from behind the Sun in late September. Now in the western reaches of Virgo, the planet will be a +1.3 magnitude object rising between 01:30 and 02:00 local time. Look for it





Another lunar eclipse! (Or at least a different look at the same one.) Dan Ostergaard used a 6" aerial-camera lens on 8" x 10", 64 ASA slide film. Exposure: 5½ hours at f/50.

Universal Time

Astronomers the world over use an unambiguous system of time reckoning based on a 24 hour clock, called Universal Time (UT). Times given in Sky Almanac are in UT unless noted otherwise. To convert UT into your local standard time, subtract the following number of hours for each time zone: EST, 5; CST, 6; MST, 7; PST, 8; Alaska and Hawaii, 10. For example, if an event is to happen at 03:00 UT on Jan. 2, then the time in EST would be 10 p.m. Jan. 1. Likewise, 03:00 UT on March 5 becomes, in PST, 7 p.m. on March 4.

Lunar Phases

Full moon: November 4, at 05:47 UT, in Cetus. Last quarter: November 11, at 16:24 UT, in Leo. New moon: November 19, at 18:04 UT, in Libra. First quarter: November 26, at 21:09 UT, in Aquarius. Apogee: November 13, at 14^h UT; perigee: November 29, at 0^h UT.

below the star Denebola in the tail of Leo.

Late last month, the Earth passed through the plane of Saturn's rings onto the northern side. At this time, and until March 3, 1980, the Sun will be on the southern side, backlighting the rings. Observers with a telescope will be seeing a complex ballet choreographed by the laws of celestial mechanics, as the rings alternately appear to tip one way and then another, depending on whether Earth is north or south of the saturnian equator at the moment.

On the morning of the 14th, the Moon, a 25% lit waning crescent, will be to the upper right of Saturn. (As seen from parts of South America and the South Pacific Ocean, the Moon will occult the planet.)

Uranus

Being directly on the other side of the Sun from us (at superior conjunction) on the 14th, Uranus isn't visible this month.

Neptune

Hard to find in the evening twilight, +7.8 magnitude Neptune is nearing the end of its recent apparition. Its elevation thirty minutes after sundown on the 1st of November is 15° (azimuth 223°); by the end of the month the elevation and azimuth will be 2.5° and 239°, respectively.

Meteors

There are three significant meteor showers this month: the Taurids (peaking on the 5th), the Andromedids (on the 14th), and the famous Leonids (on the 17th).

The Taurids appear to come from a part of the sky to the south and a bit west of the Pleiades. They aren't very plentiful (10 or so an hour), but they are bright with a number of fireballs. Which is lucky, since the peak activity comes right at full moon!

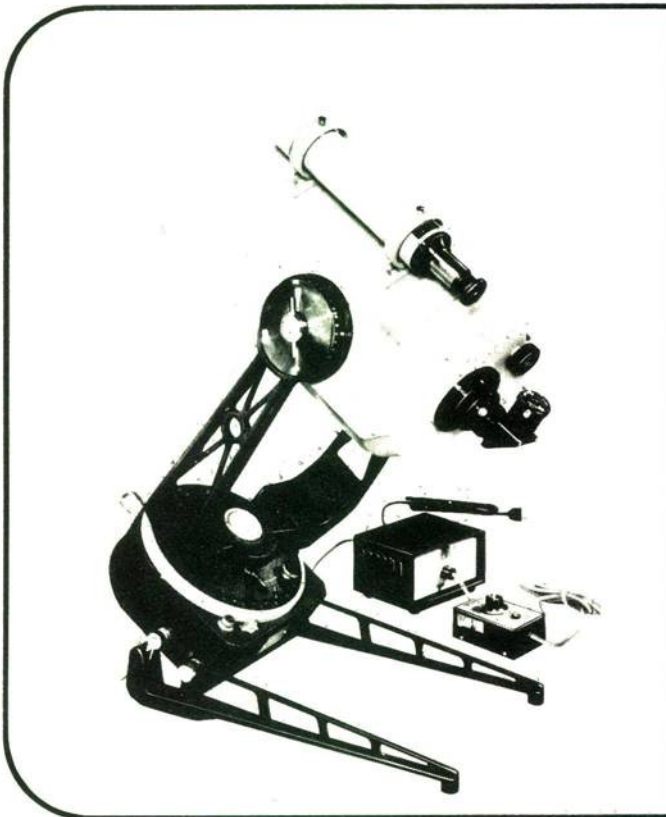
The Andromedids, as their name suggests, come from a region in Andromeda, slightly to the east of the Great Galaxy. The meteors are slow, but many are brighter than 1st magnitude, and you can expect to see 5 to 10 an hour. The Moon will not be a problem, being three days past last quarter.

The Leonids, famous on account of their great irregularity in numbers, will probably not be very strong. Their "radiant" (source point on the sky) is in the sickle of the constellation Leo. The Moon will be two days before new in phase, and therefore not a hindrance. The normal rate is between 5 and 15 meteors per hour, but on occasion can burst forth with an estimated half-million (as recorded in 1966). What'll we get this year? ☾

Performance is the First Reason You're Proud to Own a Criterion

In telescopes, "excellence is as excellence does." Our Criterion instruments, with unsurpassed optics, rank among the world's most widely praised, because they perform brilliantly, reliably and with satin-smooth, effortless ease. The more demanding the conditions of use, the more you appreciate the ability of your Criterion to deliver exciting results. Whichever advanced design tele-

scope you select, you get a superbly engineered instrument, guaranteed unconditionally. When you compare the pleasantly surprising prices you find further reason to choose Criterion. Please note that they are not "base" prices, but include everything described AT NO EXTRA COST. Only Criterion's leadership in efficient, modern precision production makes these prices possible.



Dynamax® 8 8-Inch Schmidt-Cassegrain

For Spectacular Results—Effortlessly.
Extra Features Without Extra Price.

This "never before" telescope created by Criterion gives you Schmidt-Cassegrain advantages at their best: full 8" aperture, wide field, with flawless resolution, yet weighs only 30 pounds for one-hand portability! It offers unprecedented versatility for viewing, superb telephotography, terrestrial uses, or technical applications: The exquisite optics, combined with super-precise electric drive plus variable drive corrector, combine to insure unsurpassed, unequalled ease of use because the extra features so necessary for superior results are designed-in and built-in... and INCLUDED in the price!

- ☐ AC, DC, and manual drives (variable, not just solar). You can easily dial in lunar, solar, sidereal, planetary etc. rates while observing for extra long monitoring.
- ☐ Large 8x50 finderscope has micrometer screw focusing
- ☐ Toggle switch with pilot light
- ☐ Engraved setting circles, observable from viewing position
- ☐ 3 eyepieces included
- ☐ Star diagonal, latitude adjusters, photo and telextender adaptors, and custom, fitted case. Ready for Total Performance with nothing else to buy!

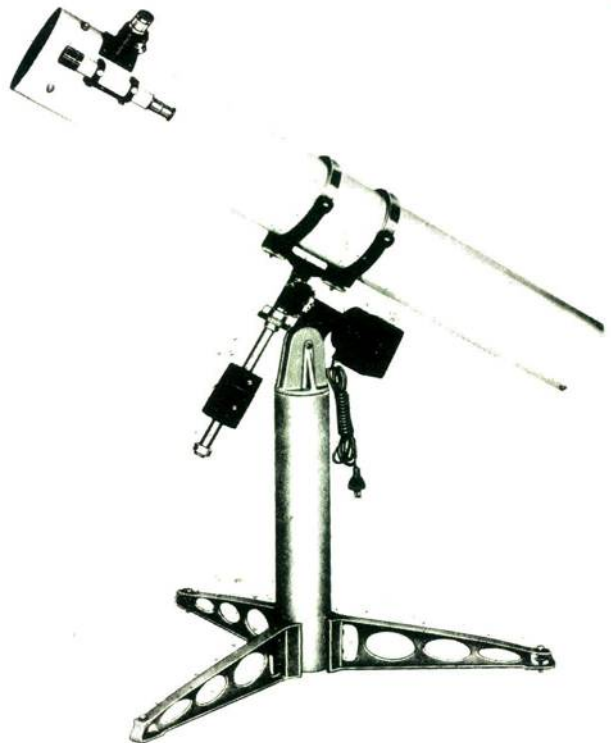
As described, complete. FOB Hartford, Conn.
Shipping wt. 65 lbs. Express charges collect.

\$875

Prompt shipment on both models. If you wish, phone us for delivery date.
To place your order, or request literature, write or call:

Criterion Manufacturing Company

Dept. CAS- 83 620 Oakwood Ave., W. Hartford, Conn. 06110/Phone: (203) 247-1696
In New York, Robert T. Little, Eastern Sales Manager (212) 834-1888



Dynascope® RV-6 6-Inch Newtonian

For Exciting Viewing, Superb Value.
Price Includes Built-In,
Precision Electric Drive!

Professionals and astute amateurs and school or college users by the thousands know the breathtaking performance, this pace-setting telescope achieves. ☐ Exquisite optical system includes f8 parabolic aluminized mirror, guaranteed to reach all theoretical limits of resolution and definition ☐ Highly accurate Electric Drive uses, regular AC, has smooth, self-acting clutch, permits manual operation ☐ Two 1 1/4" eyepieces, 70X and 140X, included. (others available) ☐ Highly stable equatorial mount with solid tripod, adjusts easily for any latitude ☐ Engraved setting circles for both right ascension and declination ☐ Tube rotates for adding cameras and comfortable viewing Easy, quick portability ☐ Smooth, brass rack-and-pinion focusing ☐ Handsome, white 50" Bakelite tube maintains perfect collimation ☐ 6x30 finderscope ☐ Fine workmanship throughout.

\$279⁹⁵

As described, complete.
FOB Hartford, Conn. Shipping wt. 77 lbs.
Express charges collect, \$15 crating charge

BOOKS FOR CLOUDY NIGHTS

	<i>Celestial Handbook</i> , 3 volume set, by Burnham	\$25.00
	<i>Revised New General Catalog</i>	\$15.00
	<i>Wanderers in the Sky</i>	\$ 8.50
	<i>Space Science & Astronomy</i>	\$14.00
	<i>Galaxies</i> , by Shapley (soft)	\$ 6.00
	<i>Atoms, Stars & Nebulae</i> (soft)	\$ 6.00
	<i>The Milky Way</i> , by Bok (soft)	\$ 6.00
	<i>Our Sun</i> , by Menzel (hard cover)	\$15.00
	<i>Earth, Moon & Planets</i> (soft)	\$ 4.00
NEW	<i>Stars & Clusters</i> , by Gaposchkin	\$22.50
	<i>Sundials</i> , by Mayall (hard cover)	\$ 9.95
	<i>Astronomy: A Handbook</i> , by Roth	\$18.00
	<i>U.S. Observatories</i> , soft cover	\$ 6.95
	<i>Cambridge Encyclopaedia of Astronomy</i>	\$35.00
	<i>Russell W. Porter</i> , a biography	\$10.95
	<i>The Messier Album</i>	\$11.50
NEW	<i>Experiments in Astronomy for Amateurs</i>	\$ 8.95
NEW	<i>The Cloudy Night Book</i>	\$ 4.95
	<i>Mars</i> , by P. Lowell — LIMITED REPRINT	\$16.50
	<i>Telescopes for Skygazing</i> , by Paul	\$10.95
	<i>Outer Space Photography</i> , by Paul	\$10.95
	<i>All About Telescopes</i> , by Brown	\$14.00
	<i>Sky Shooting</i> , by Mayall	\$ 4.00
	<i>Optics & Optical Instruments</i>	\$ 4.00
	<i>Sundials, Their Theory & Construction</i>	\$ 4.00
NEW	<i>The History of the Telescope</i> , by King (soft)	\$ 7.50
NEW	<i>The Amateur Astronomer</i> , by Rukl (hard cover)	\$ 9.95
NEW	<i>Star Maps</i> , by W.R. Fix	\$ 8.95
	<i>Star Names, Their Lore & Meaning</i>	\$ 5.00
	<i>A Short History of Astronomy</i>	\$ 6.00
	<i>History of Astronomy from Thales</i> to Kepler	\$ 4.50
	<i>Great Ideas and Theories</i> of Modern Cosmology	\$ 4.50
	<i>Planets, Stars & Galaxies</i>	\$ 3.25
	<i>Friendly Stars</i> , by Martin	\$ 2.75
	<i>Restless Universe</i> , by Born	\$ 4.50
	<i>Music of the Spheres</i> , by Murchie Vol. I.	\$ 3.50
	Vol. II.	\$ 4.50
	<i>Stellar Structure</i> , by Chandrasekhar	\$ 6.00
	<i>Structure & Evolution of Stars</i>	\$ 5.00
	<i>Radiative Transfer</i> , by Chandrasekhar	\$ 5.50
	<i>Einstein's Theory of Relativity</i> , by Born	\$ 4.00
	<i>Einstein: The Man and His Achievements</i>	\$ 2.00
	<i>Space, Time, and Matter</i> , by Weyl	\$ 4.00
	<i>Philosophy of Space & Time</i> , by Reichenbach	\$ 3.75
	<i>Geometry, Relativity &</i> <i>the Forth Dimension</i>	\$ 3.00
	<i>Introduction into Astrophysics</i>	\$ 2.75
	<i>Strange Story of the Quantum</i>	\$ 3.00
	<i>Atomic Nucleus</i> , by Kersunsky	\$ 3.50
	<i>Concept of Energy Simply Explained</i>	\$ 3.00
	<i>Nature of Light & Color in the Open Air</i>	\$ 4.00
NEW	<i>The Discovery of Neptune</i> , by Grosser	\$ 3.25
NEW	<i>Search for Extraterrestrial</i> <i>Intelligence</i> , by NASA	\$ 3.25
NEW	<i>The Story of Maps</i> , by Brown	\$ 7.00



We process black-and-white astrofilm.

Let The Astronomical Unit process your special shots of the Universe. We will professionally develop and print your Spectroscopic, SO-115, or any other 35-mm B&W, using the best fine-grain developers. Prints are made only on the fine Kodak Resin Papers.

Processing, per roll	\$1.69
Prints, 5 x 7, ea.	.75
8 x 10, ea.	2.00

We print only the shots you request after inspection of the negatives. Please include descriptions of objects photographed. Add \$1.00 postage and handling for prints.

THE ASTRONOMICAL UNIT

"Your Midsouth Celestron® Representative"

3704 JOHN F. KENNEDY BLVD.,
NORTH LITTLE ROCK, ARK. 72116

501-771-0940

OBSERVING AIDS

<i>Lunar Maps</i> , 10.5" disk	\$ 0.75
<i>Messier Catalog</i> , card listing	\$ 0.75
<i>Finest Deep-Sky Objects</i>	\$ 1.75
<i>Some Bright Visual Binary Stars</i>	\$ 1.25
<i>Lunar Quadrant Maps</i>	\$ 7.00
<i>Selected List of Star Names</i>	\$ 1.25
<i>The Planetary Nebulae</i>	\$ 1.50
<i>Visual Observing of Double Stars</i>	\$ 1.25
<i>How to Become an Astronomer</i>	\$ 2.50

STAR ATLASES AND CATALOGS

<i>Popular Star Atlas</i>	\$ 5.50
<i>Norton's Star Atlas</i>	\$17.00
<i>Atlas of the Heavens</i> , Deluxe	\$18.00
Field	\$ 6.00
Desk	\$ 6.00
<i>Atlas Borealis</i> (northern)	\$27.50
<i>Atlas Eclipticalis</i> (Ecliptic)	\$29.50
<i>Atlas Australis</i> (southern stars)	\$27.50
<i>Handbook of the Constellations</i>	\$24.00
<i>Atlas of Deep Sky Splendors</i>	\$36.00

Self-help Publications for the Amateur Astronomer

By Clay Sherrod

Written expressly for the amateur who wants to put meaning into his astronomical studies. Author is well-known astronomy popularizer CLAY SHERROD. Each monograph is offset printed on 8½ x 11 paper with many illustrations and tables.

- 1) *The Amateur's Study of Comets*
in 3 parts
- 2) *The Amateur's Study of Jupiter*
- 3) *Scientific Studies of Saturn*
- 4) *Mars, The Red Planet*
- 5) *Astrophotography* (Koed and Sherrod)
a fine guide complete with exposure
tables and film specs
- 6) *Visual Photometry of Minor Planets*
- 7) *Lunar Topography — Amateur*
Projects
- 8) *Counting Sunspots*
- 9) *Observations of Meteors*
- 10) *Construction of Astro Light Curves*
- 11) *Periodic Comets and Annual Meteors*,
a descriptive list
- 12) *Constellation Projects*
set of 10 constellation charts
- 13) *Optics Cleaning*
- 14) *Collimating a Newtonian Reflector*
- 15) *How to Organize an Astronomy*
Club
- 16) *Observing Variable Stars*

Please include \$0.50 for postage and handling with each order.

ASTRO FILM PROCESSING! WRITE FOR SPECIFICATIONS.

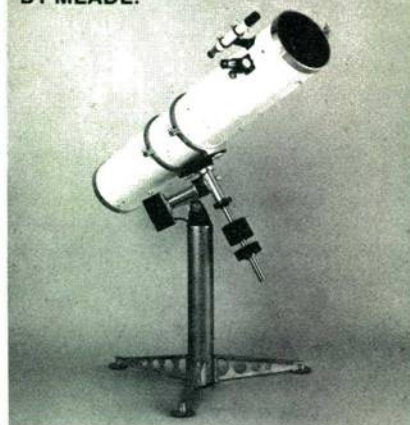
Advanced Instruments for Amateur and Professional Astronomers

PLS Solar System Camera for Vibrationless Photos	\$495
SSP Solid-State Stellar Photometer	\$545
OD-1 Professional Drive Corrector, 30 Watts	\$160
Kokich Roll-Film Cold Camera — The Finest We've Seen	\$195

Cameras for Astrophotography

Olympus OM-1, with f/1.8 Lens — The Most Popular	\$279
Pentax K-1000, with f/1.8 Lens — Economical, Yet Reliable	\$199

NEWTONIAN TELESCOPES BY MEADE:



MEADE TELESCOPE LIST

Model 628, 6" f/8 with drive	\$ 380
Model 618, 6" f/8 w/o motor	\$ 340
Model 645, 6" f/5 with drive	\$ 390
Model 635, 6" f/5 w/o drive	\$ 350
Model 826, 8" f/6 with drive	\$ 490
Model 816, 8" f/6 w/o drive	\$ 430
Model 856, 8" f/6 photographic	\$ 770
Model 880, 8" f/6 heavy duty deluxe	\$ 995
Model 1060, 10" f/6 heavy duty deluxe	\$1285
Model 1266, 12" f/6 heavy duty deluxe	\$1675

WE PAY ALL PACKING AND CRATING CHARGES!!
Shipping Charges Collect

USED EQUIPMENT

We carry many used telescopes and accessories in stock at low, low prices! We may have what you are looking for — give us a call!

In addition, we will take trade-ins when you get ready to move up to that "bigger scope."

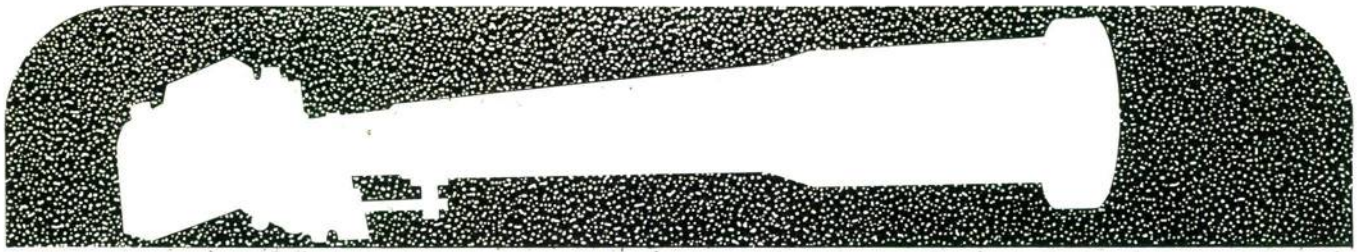
Examples of used scopes now in stock:

- 4" Unitron Photo-Equatorial
- 6" Edmund Heavy Duty Equatorial
- C-8, Tripod, Wedge
- C-90 Astro Scope, w/wedge

Call or write Clay Sherrod or Tom Koed for consultation in astronomy, photography and the BEST price on your next purchase.

Catalogs and specifications, \$1.00.





PHOTOGRAPHY IN ASTRONOMY

High Resolution Astrophotography

by
Steve Reed

High resolution photography of the Moon and planets is a challenging hobby: It demands the very best from you and your telescope. It's also a golden opportunity for city-bound observers, since the first (and perhaps most important) requirement is excellent atmospheric steadiness — you don't need a dark sky as the deep-sky astrophotographers do.

But nights of superb seeing are relatively rare. It's desirable to perfect both your equipment and technique so you can take full advantage of those occasional perfect nights. When the atmosphere is right, you'll want to be ready for it.

Telescope and Drive

For the highest resolution, you'll need an equatorially mounted, motor-driven telescope. The larger the aperture and longer the focal length, the more detail you'll be able to record on film. Telescopes in the four to six-inch range can do fine work under good conditions.

You should keep the telescope precisely collimated and accurately polar aligned. Collimation is important, and it's often overlooked in lunar and planetary photography. If your optics aren't delivering the best image they can, then you won't get the best pictures possible. How can you check this? It's simple — using your highest-power eyepiece, observe a medium-bright star critically. You should see a clean symmetrical Airy disk with one or two diffraction rings when the star is at best focus, and the image of the star should look exactly the same when the eyepiece is a little inside or outside focus. (See "Star-Test Your Telescope," *ASTRONOMY*, October 1976.) If your telescope is portable, check the collimation before every photo session



Using the eyepiece projection technique, Jim Rouse captured this fine image of Mars showing a small southern polar cap, Syrtis Major, and Sinus Sabaeus during the 1973 opposition of that planet. The effective focal ratio of his 8" f/7 Newtonian telescope was increased to f/105; he used a 5 second exposure on High Contrast Copy film.

in case something's gotten jiggled.

Next is the accuracy of the telescope's drive system: A smooth accurate drive is essential for the highest quality results. Short-term periodic or other errors in a poor drive system can cause your photos to lack sharpness. While solar or sidereal rate drives are fine for planetary photography, you'll need an electronic drive corrector to adjust to the lunar rate (which is about 6% slower than sidereal) for extremely high-resolution lunar photography.

Putting the Image on Film

The focal length of most telescopes simply isn't long enough to make useably large planetary images. The image of Saturn's rings or the disk of Jupiter at the focus of a telescope with a 64-inch focal length is about 1/80th of an inch. Even if you get the negative enlarged ten times, the planet is still diminishingly tiny.

With the so-called eyepiece projec-

tion technique, an eyepiece is used to project a magnified image of the planet onto the film plane. The camera's lens is not used. With any particular eyepiece, the greater the projection distance, the bigger the image is. At the same time, the enlarged image gets dimmer.

Eyepiece projection greatly increases the effective focal length (EFL) of the telescope. If you calculate the resulting focal length, however, you'll be able to use it to derive the system f/number, image size, and photographic magnification. First you'll need to calculate the projection factor (M) that the eyepiece gives:

$$M = \frac{\text{Projection Distance}}{\text{Ocular Focal Length}} - 1$$

Next, calculate the effective focal length by multiplying the telescope focal length ("first focus") by the projection factor:

$$\text{EFL} = (\text{first focus EFL}) \times M$$

Once you know the projection factor (M) you can also find the system f/number by multiplying the first focus f/number by M:

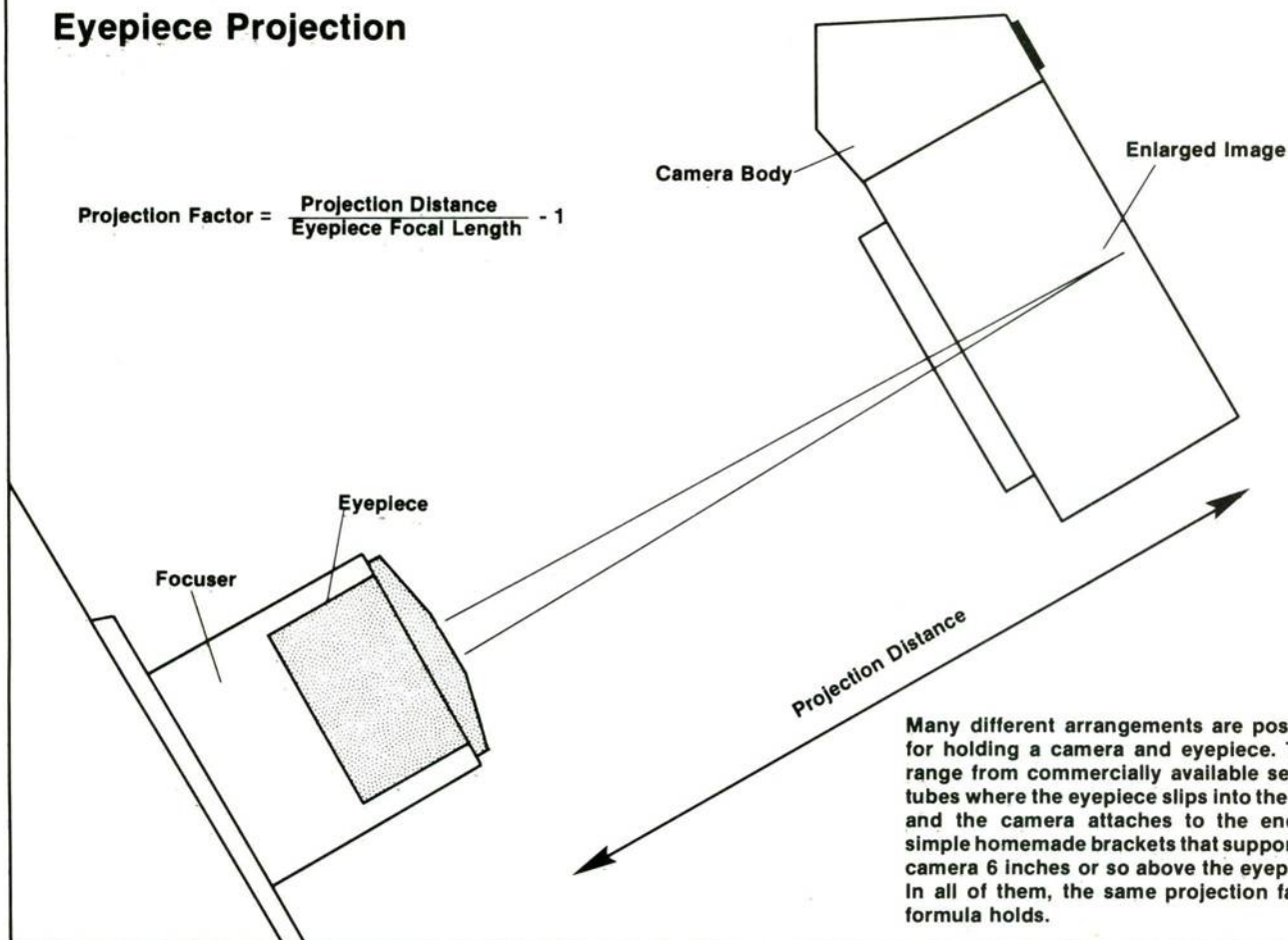
$$\text{System f/\#} = (\text{Telescope f/\#}) \times M$$

For example, if you find the projection distance is 6" and the eyepiece focal length is 1" (or use 25 mm — but don't mix units), then the projection factor is 5. With a projection factor of 5 for an 8-inch f/8 telescope (with a first focus EFL of 8 x 8 = 64 inches), the system EFL would be 64 x 5 = 320 inches. In this example, then, the system f/number would be 8 x 5 or f/40.

The system f/number is a useful value to know because it's one of the three critical things you need to know

Eyepiece Projection

$$\text{Projection Factor} = \frac{\text{Projection Distance}}{\text{Eyepiece Focal Length}} - 1$$



Many different arrangements are possible for holding a camera and eyepiece. They range from commercially available sets of tubes where the eyepiece slips into the tube and the camera attaches to the end, to simple homemade brackets that support the camera 6 inches or so above the eyepiece. In all of them, the same projection factor formula holds.

to determine the exposure time: the f/number, the film speed, and the brightness of the celestial object you're photographing. You can use the table of suggested exposures for the moon and planets on page 47 (or refer to "Exposure in Astrophotography," ASTRONOMY, August 1978, for a more detailed method of determining exposures).

Figure Out Your Focal Length...

The images of the planets, especially, are very small unless the focal length of the system is very great. But making the focal length long means that the image gets dimmer, the exposure gets longer, and there's more wobble and vibration to make the picture fuzzy. You're seeking, basically, the shortest focal length that will give you an acceptably large image.

Begin by figuring how large the image should be: it's realistic to try for a 1/10" to 1/3" (2.5 to 8 mm) image size for Venus, Mars, Jupiter, and Saturn. Enlarged ten times, the final image will come out several inches across, which looks pretty good. To figure the image size on your negative, use this formula:

$$\text{Image Diameter} = \frac{(\text{Object Diam. in arc-sec}) \times \text{EFL}}{206,000}$$

You'll find the object diameter (in seconds of arc) in Sky Almanac every month, along with other useful information about the placement of the object in the sky and where to look for it. The focal length, of course, depends on your telescope, and is what you're trying to find. Start with a few "guesstimates" and see how big the image comes out; then work backwards to find out which eyepieces will work best with your projection system.

Let's pursue our earlier example a bit further. With a focal length of 320" given for the telescope and eyepiece projection system in the example, let's see how big Jupiter comes out. If Jupiter has an equatorial diameter of 42 seconds of arc, then the image will be:

$$(42 \times 320 \text{ inches}) / 206,000 = 0.065"$$

That's a bit small, only 1/16th inch, so it would help to double the focal length to 640" or so. Working backwards, the projection magnification needed is 10. If you replace the 1" eyepiece that gave a projection factor 5 with a 1/2-inch focus eyepiece, using the same projection distance, you'll get a new projection factor of 11. Working that back through the equations gives you an EFL of 11 x 64 or 704 inches, and thus a Jupiter image size of:

$$(42 \times 704 \text{ inches}) / 206,000 = 0.14 \text{ inches}$$

This is adequate in scale; enlarged ten times or so the image will be 1 1/2 inches across. Next, we'll figure the exposure time. The f/ratio is:

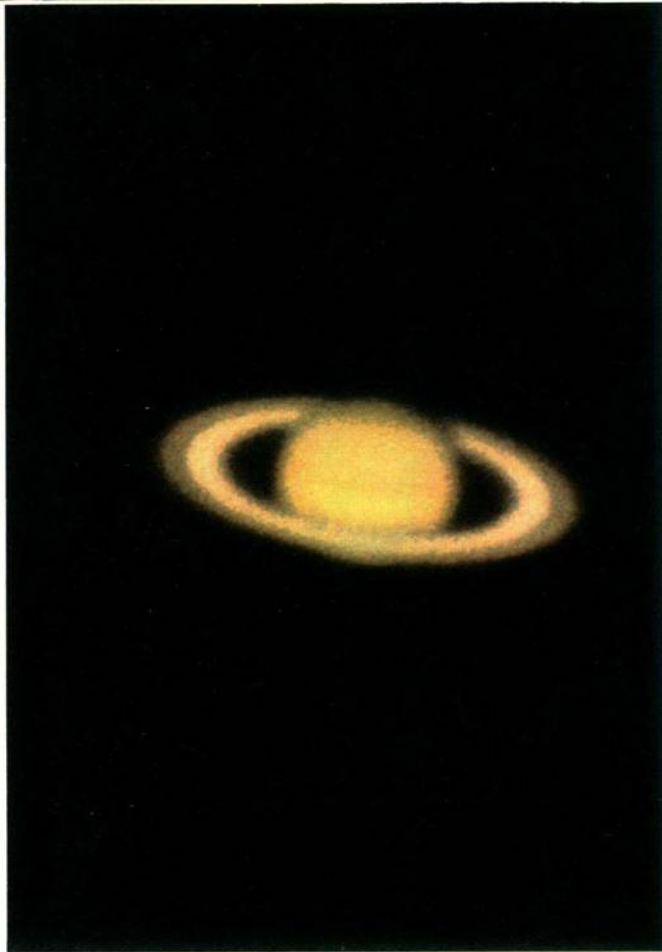
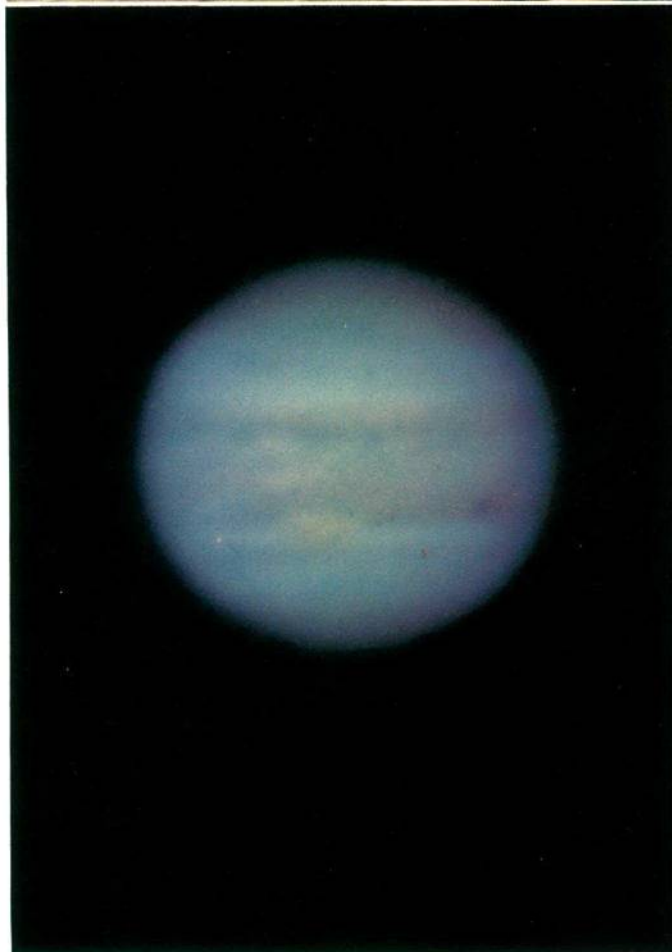
$$704 \text{ inches} / 8 \text{ inches} = 88$$

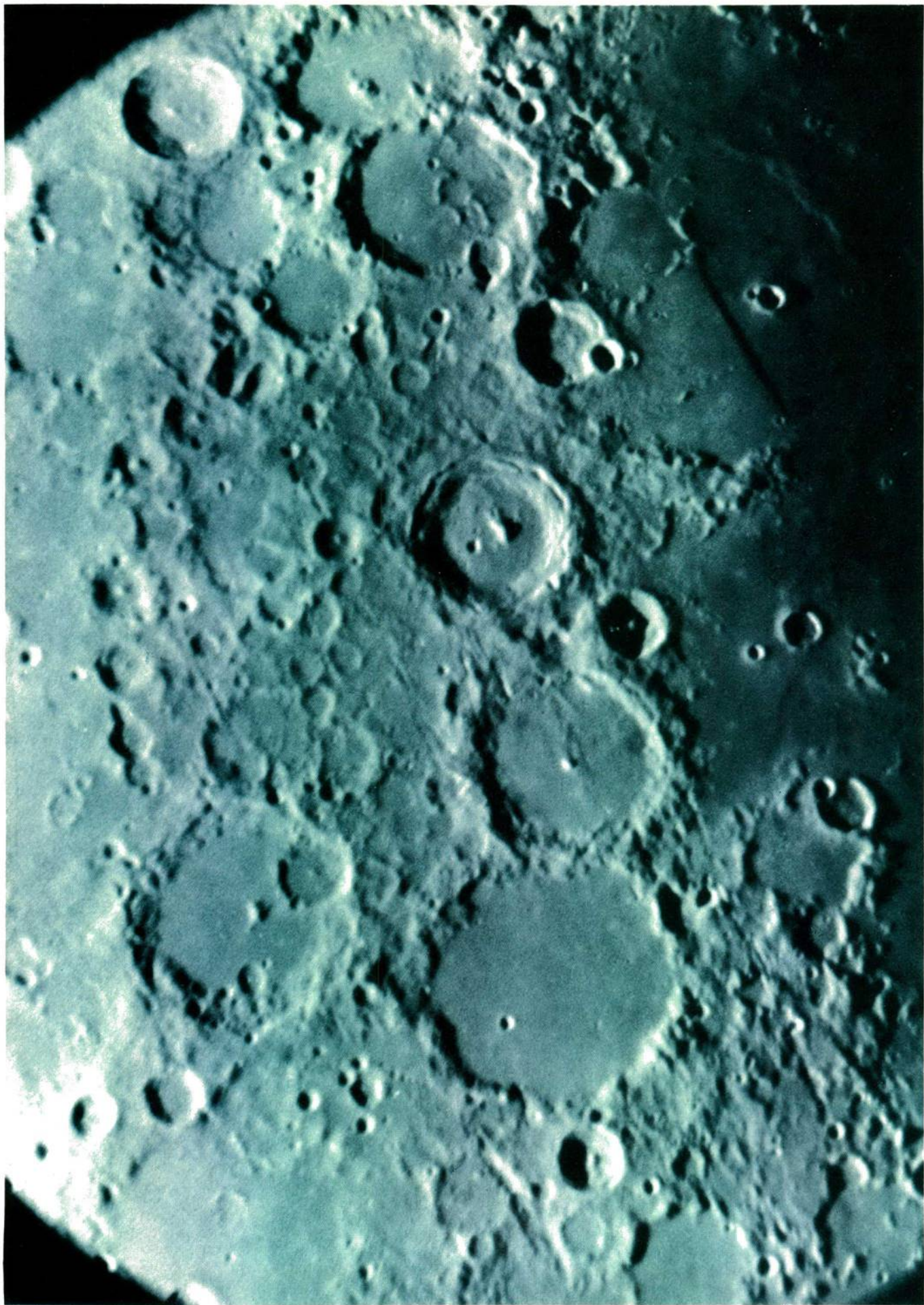
Using fast color film (400 ASA), the exposure comes out about 1/2 second according to the table in this article, and about 3/4 second using the formulas in the "Exposure in Astrophotography" article. In practical terms, you'd want to try a wide range of exposures from 1/4 or 1/8 of a second through several seconds.

It's All Gotta Come Together...

The essence of superb high-resolution photography is getting it all together at the same time. Everything has to be right. You'll need good

The Straight Wall on the Moon and Jupiter showing both its Red Spot and the shadow of its satellite Io were photographed by Steve Reed with a Celestron 14 telescope. He used a 16 mm eyepiece to obtain a focal ratio of f/122. For the Moon, he used an exposure of 2 seconds on High Speed Ektachrome; for Jupiter, a 2-second exposure on Ektachrome 64. Saturn was photographed by Thomas Peterson, also using a C-14, in a 3-second exposure on High Speed Ektachrome at f/136 using a 20 mm eyepiece for projection.





seeing, of course, but that's not enough; you also need perfect focus, satisfactory tracking, freedom from vibration, adequate image size, correct exposure, the right film for the job, and last but not least, good darkroom technique to display all the detail you captured on the negative.

Now, Put Film in the Camera...

Now that you've seen how difficult astrophotography can appear to be, let's look at the specifics in detail. What seemed so complicated taken altogether will seem to simplify when it's broken down. After all, you're ready to start taking pictures now!

We'll go through the steps one at a time and you'll see how each works and why it's important to get it right. To begin the evening's observing, set up your equipment, check that the telescope is collimated to give top image quality, check that the seeing is good, check that you've got pretty good polar alignment, and choose your target object.

Focusing: High resolution photography requires precise focusing. The standard matte-finish focusing screen in most cameras makes focusing difficult and imprecise because the image is too dim to see well. The simplest remedy for this is to use a camera body that allows you to remove the standard focus screen and substitute a perfectly clear, "aerial image" focusing screen. This makes it relatively easy to focus accurately. If possible, use a 2x to 5x focusing magnifier (available with some makes of camera) to further increase focusing accuracy.

Vibration at the Moment of Exposure: At very long focal lengths, the slightest amount of vibration can reduce overall image sharpness. With smaller and less massive telescopes, even the mirror slap and shutter vibration of SLR cameras is sufficient to blur your photos. Vibration can easily be eliminated by utilizing the "black card method" (sometimes called the "hat trick").

Cover the end of the telescope (without actually touching it) with a black card. Lock the camera shutter open. Next, after all vibrations have damped, remove the card for the desired length of time and then replace it — again without touching the telescope. While the end of the scope is still covered, close the camera's shutter.

If your telescope is massive enough

Large aperture is not necessary for high resolution astrophotography. Tim Tomljanovich used a 6" Newtonian reflector and projection with a 12 mm eyepiece to obtain this image of Ptolemaeus, Alphonsus, Arzachel, and the Straight Wall. He used Tri-X film and a 1/2 second exposure time.

Eyepiece Projection Exposures

	Film ASA	Moon	Venus	Mars	Jupiter	Saturn
f/32	100	1/4	1/60	1/4	1/2	1
	400	1/15	1/250	1/15	1/8	1/4
f/50	100	1/2	1/30	1/2	1	2
	400	1/8	1/125	1/8	1/4	1/2
f/70	100	1	1/15	1	2	4
	400	1/4	1/60	1/4	1/2	1
f/100	100	2	1/8	2	4	8
	400	1/2	1/30	1/2	1	2
f/140	100	4	1/4	4	8	—
	400	1	1/15	1	2	4

to damp out the vibration caused by releasing the shutter, use an air-release cable (as opposed to a metal, spring-type cable release) to keep from inducing any vibration from your hands. Also, if your camera permits it, manually retracting the instant-return mirror in your camera before exposure will help minimize vibration. Needless to say, if you attempt photography when there's enough wind or breeze to jiggle the telescope, all the care you've taken to eliminate vibration will be in vain.

Choosing the Correct Exposure Time: The correct exposure time depends on several variables which include: subject brightness, system f/number, film speed, transmission loss in the optical system, and atmospheric transparency. The best way (after you've found the "ballpark figure" from the table) to determine the optimum exposure time with your equipment is to make a series of test exposures, bracketing widely.

If, for example, the exposure "should" be 1/4 second, try twice, four times, half, and a quarter of that also — 1/2, 1, 1/8, and 1/15 in this case. Keep track of the exposures in a notebook and, after examining the processed negatives, note the exposure time that produced the best negative for each subject. In general, it's best to use relatively short exposures to minimize the effects of varying seeing conditions and tracking inaccuracies.

Film: With the wide variety of films available today, which should you use for lunar and planetary photography? For high resolution photography, desirable film characteristics are: fine grain, high contrast, and a moderate-to-high film speed (ASA rating).

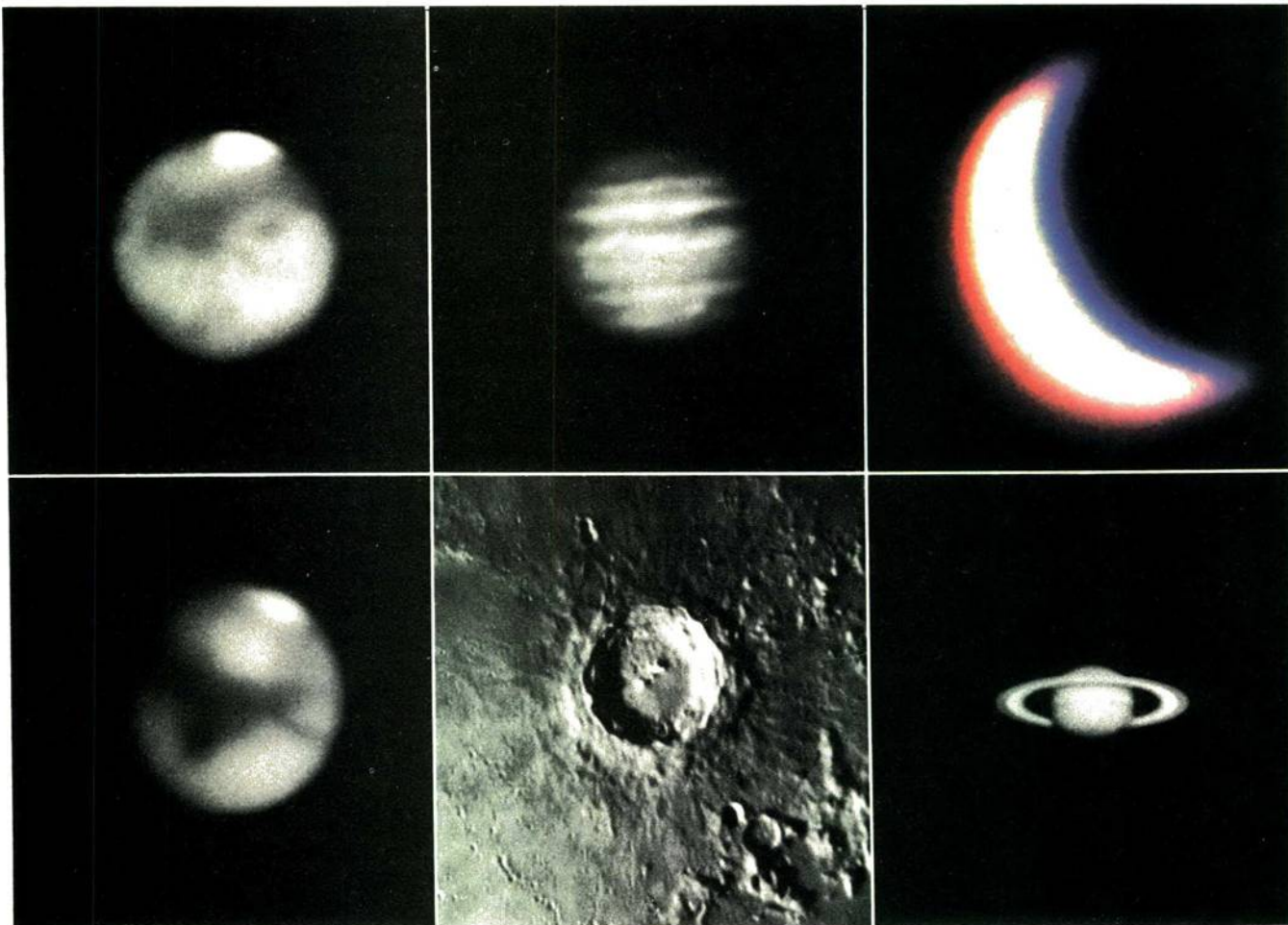
Ordinary black and white films for general use (i.e., Tri-X and HP-5) do not have the very fine grain and contrast needed for planetary (or whole-disk lunar) photography, though they do work pretty well when you're getting started.

Two special purpose Kodak films, SO-115 Technical Pan film and High Contrast Copy film, have very fine grain and very high contrast. When processed as recommended by Kodak, however, both films lack the full tonal range that makes for the most appealing photos. Fortunately, with specialized processing techniques, these films are vastly superior to other films for high resolution photography. Because of SO-115's greater contrast and speed, it's probably the better of the two films.

Film Processing Tips

Specialized processing consists of using a compensating developer, such as H&W 4.5, for processing the film. You'll probably get good results using it double strength (20 ml of developer concentrate plus water to make 8 oz. of solution) for 10 minutes at 68° Fahrenheit. To boost contrast, mix in a small amount of D-19 (1/2 to 1 oz.) if desired. Avoid working above 75° F because the emulsion tends to soften and swell. Remember to keep the temperature of all solutions — developer, stop bath, fixer, and wash water — within 2° F of each other to avoid reticulation with these specialized films. Reticulation looks like curled film grain.

In most home darkrooms, the temperature of the wash water can vary substantially with the seasons. Either wash the film from a large bottle of water at the same tempera-



ture as the solutions, or for greater ease in processing, adjust the temperature of the solutions to that of the wash water.

Printing the Negatives

Since these special films produce very high contrast negatives, it won't be necessary or desirable to print them on contrasty paper. Usually #2 to #2½ paper is best: High contrast papers will only emphasize grain. In general, it's desirable to obtain a high contrast negative and print on low or medium contrast paper.

Because of the high contrast inherent in SO-115 and High Contrast Copy film, filters are of little value for astrophotography when using them. Any possible gain in contrast resulting from using a filter is more than outweighed by the detrimental effects caused by the greater exposure time needed when using the filter.

For lunar terminator photography, the ultra-high contrast of SO-115 and High Contrast Copy film may cause you to lose the subtle details along the terminator. In this situation, a general purpose fine grain film like H&W Control or Plus-X (with fine grain development) may be a better choice.

...and Color, Too!

For color photography, Kodachrome 25 offers the finest grain and highest contrast. Unfortunately, it's too slow to

be useful. The next best choice is Kodachrome 64 film, which performs extremely well when photographing Venus, Mars, Jupiter, and the Moon. However, K64 is also a relatively slow film, so the exposure time for Saturn (which is quite a bit fainter than the other major planets) is fairly long. For this reason, Ektachrome 200 or Ektachrome 400 film probably is a better choice when photographing Saturn.

If you use Kodachrome film, you'll have to let a commercial lab process the film. It's a good idea to make the first exposure of each roll a "normal" picture so the photolab's automatic film cutter, which uses the first frame as the starting point for cutting, won't slice your planetary images down the middle!

One final point on the choice of a suitable film: If your telescope's drive is erratic or has large periodic errors (as spur-gear drives tend to), you may get better results by using the faster films with shorter exposure times. This means that SO-115 (at approximately 100 ASA) might be too slow. You'll then have to abandon it and try the far less suitable, relatively grainy, low-contrast speed champs such as Tri-X.

Although these techniques are

Upper and lower left: Mars was recorded by E. Ken Owen using a 10" Newtonian. Using a 4 mm orthoscopic eyepiece for projection to f/185 and f/250 respectively, he captured Mars showing Solis Lacus (upper) and Syrtis Major. Middle, upper: George Nalishnik used his homemade 8" Maksutov for this picture of Jupiter. Middle, lower: Howard Zeh used a 8" Newtonian for this high resolution view of Copernicus. Right, upper: Venus, showing atmospheric chromatic aberration, was recorded with a 10" Newtonian by Phillip Imbrogno. Right, lower: In 1971, Saturn's rings, then wide open, were recorded with Bob Kimmel's 8" Newtonian.

mainly a springboard on which to build your own experience, they'll allow you to obtain consistently high-quality photographs. But remember: Even with the best equipment and technique you can't obtain high resolution photos unless the seeing conditions are excellent. Wait for nights when the seeing is excellent and then shoot a lot of film. 🍷

Steve Reed is employed by the U.S. Air Force as a Quality Assurance Representative working at Hughes Aircraft Company, Fullerton, California. He was formerly employed as the Customer Services Manager at Celestron International, where he wrote (or revised) the operating manuals for Celestron telescopes and accessories.

EVERYONE TALKS ABOUT IT...

ORION'S DONE SOMETHING ABOUT IT!

Fast service, low prices, personal attention, big selection... everyone says they've got it. At Orion Telescope Center, we don't just talk about it, we prove it to our customers every day. Write for our catalog today and find out for yourself! We ship most orders within 24 hours, give honest and helpful answers, guarantee everything, and treat you like a friend.

Try us, you won't be disappointed!

CELESTRONS AT SPECIAL SALE PRICES!

C-8, C-5, C-90, and all accessories reduced now!

You can save hundreds of dollars on a new Celestron now at Orion. Our prices are so low, we are not allowed to print them by agreement with Celestron International. You don't have to sacrifice service or convenience just to get a low price at Orion. Many exclusive accessories, too. Call or write today!



Lightweight Dewcap For Celestron 8

Having trouble with dew build-up on your C-8? Our lightweight dewcap shields the corrector plate from falling dew, keeping build-up to a minimum. It's made of resin coated fiber; the same tubing used by major telescope manufacturers. It mounts in seconds—slides right over the front cell of your C-8 and secures with two thumbscrews. Allows you to use your counterweight set at the same time as the dewcap. Orange finish matches your C-8 perfectly. **#5180—\$29.95.**



NEW! Accessory Tray For Celestrons

Keep your accessories at your fingertips, away from harm. Handy aluminum tray mounts in seconds, without tools; secure & sturdy. Support brackets attach to tripod legs with a screwdriver, no drilling. Brackets stay attached to legs, out of the way, even when tripod is folded for storage. Convenient holes fit eyepieces & accessories. Perfect for drive corrector. For 1.25" eyepieces (C-8) **#5721—\$39.95.** For .965" eyepieces (C-5, C-90), **#5722—\$39.95.**



No-Tool Knob Set For Celestron 5 & 8

Tired of using a wrench to set-up and adjust your C-5 or C-8? Replace those ordinary bolts with our handy stud knobs. No tools needed. Full set of 12. **#5612—\$11.95.**



The Astronomer's Flashlight

A super handy, heavy-duty flashlight with night-vision red filter, special diffusion lens for soft illumination, both bright & dim bulbs, spare bulb holder, belt clip, molded switch guard. High-impact Cyclocac, brilliant yellow and black. Stands up for hands-free use. **#5701—\$7.95.**



Add Electric Declination Control To Your C-8

Our popular unit gives you the advantages of vibration-free electric declination, for error-free guiding, at a very moderate price. Designed specifically for astrophotography, matches the DriveSpeed Control right-ascension guiding speeds. Can be powered and controlled by a dual-axis AccuTrack OmniGuide unit such as the 3119 or 2119B, or by the accessory hand control with internal battery. It mounts in a few minutes, without drilling, using ordinary tools. Tucks under fork arm, doesn't interfere with storage. Power cable unplugs when not in use. Allows for manual dec. adjustments at any time. Model 3901 is for older C-8's with holes in fork arms. Model 3902 (illustrated) is for current model C-8's. **#3901—\$39.95. #3902—\$39.95.** Hand control with battery and cable. **#3909—\$9.95.**



Sun & Moon Filter For Reflectors & Celestrons

This is a revolutionary new thin-film mylar filter, which easily outperforms other film filters. Convenient magnetic mount attaches to secondary mirror support. Pops on or off in seconds, ventilated to reduce heat build-up. Safe to use! (Specify telescope.) For Celestron 8, **#5168—\$33.00.** For all 8" Newtonian reflectors except Dynascope, **#5167—\$33.00.** For Celestron 5 and all 6" Newtonians except Dynascope, **#5169—\$29.00.**



Swivel Adapter For Piggy-back Camera Mount

Attaches to your Celestron piggy-back camera mount (not included) and lets you swivel your camera 30° in any direction. You can guide on a convenient nearby star while photographing off to one side. Also suitable as a tangent mount for a small guide scope such as the C-90. **#5138—\$14.95.**



Polar Alignment Adjuster For C-5 & C-8

Our design gives you a centered fingertip wedge tilt adjustment, so it's smooth & precise. Mounts in minutes, no drilling. Easy to set up & align your telescope without levelling your tripod, for accurate reading setting circles & accurate drive rate. **#5421—\$24.95.**



Porta-Pac Rechargeable Energy Cell

Away from home or car, the Porta-Pac gives you the power you need to operate your telescope drive all night on a single charge, when used with an AccuTrack Inverter or Drive Speed Control. Small, lightweight (5 lbs.), spillproof and maintenance free. Charger included. Cigarette lighter plug output. 12 volts, 5.0 amp-hours. **#2352—\$49.95.**



12 Volt to 117 Volt Power Inverter

Where regular AC power is unavailable, the AccuTrack Inverter changes 12 volt DC to 117 volts AC, regulated at exactly 60.0 Hz for accurate drive speed. Very efficient for maximum operating time. Works from cigarette lighter plug or with Porta-Pac Energy Cell. 10 watt capacity, perfect for all telescopes up to 8". **#2351—\$39.95.**



Astroscan 2001 Telescope Only \$159.95

You can save on your new Astroscan and accessories now at Orion. This is one of the best telescope values around. Ask for free brochure. Astroscan 2001 Telescope, **#9605—\$159.95.** Image Erecting Prism, **#7401—\$39.95.** Barlow Lens/Camera Adapter, **#7402—\$49.95.** Tripod Mounting Bracket, **#7403—\$17.95.** Nylon Tote Bag, **#7404—\$13.50.** Rubber Eyeguard, **#7405—\$1.79.** Camera T-ring (specify camera), **#5200—\$12.50.**



AccuTrack—The Leader In Electronic Telescope Control Systems

For easier and more accurate astrophotography, you deserve AccuTrack's superior engineering. The largest line available, a model for every need. Many unique features including our OmniGuide dual-axis joystick hand control. Thousands have been manufactured in our own facility. Two year warranty. Don't buy another brand without checking our catalog for complete information and selection guide. (Dealer inquiries welcome.)

NEW! AccuTrack

MiniDrive
Get started with a genuine AccuTrack at an unbeatable price. Full range speed control, tracks at Sidereal, Solar, Lunar, & Planetary rates. Calibrated tracking rate control, fast & slow correction buttons. Runs on 12 volts DC, has 10 ft. cable with cigarette lighter plug. Just plug in your scope, ready to use. **#2361—\$49.95.**



Compact Series

AccuTrack
The most efficient available. 110 volt or 12 volt powered, 10 watts, solid-state speed indicator, switch selected tracking rates. Available with Celestron tripod mount. Remote hand control. Single-axis model, (illustrated) **#3117—\$79.95.** Dual-axis OmniGuide model for Celestron 8, **#3119—\$109.95.**



Deluxe Series AccuTrack

All the features of Compact Series, with increased accuracy, automatic Star Tracker input, 15 watt capacity, deluxe cables, heavy duty construction. Single-axis model, **#2117—\$119.95.** Dual-axis OmniGuide model for Celestron 8 & our dec. motor drive, **#2119—\$149.95.** Dual-axis OmniGuide model for other telescopes with dec. motor drives, **#2118—\$159.95.**



AccuTrack AutoGuide Star Tracker

Locks on guide star and sends signals to your AccuTrack Deluxe or Digital Drive Speed Control. Makes guiding corrections automatically. Perfect for Celestron off-axis guider. The most popular star tracker in the world. **#2200—\$124.95.**



Digital Crystal Controlled AccuTrack

The world's most advanced system available to the amateur. 15 or 20 watt power capacity, single or dual axis. Prices start at \$269.95. Complete details in catalog.



UNBEATABLE GUARANTEE

If you're not happy with any purchase, return it in new condition within 30 days for a full refund. No hassle.

IMPORTANT INFORMATION

\$1.00 service charge on all orders under \$15.00.

California residents add 6% tax. If you send check or money order, we pay shipping charges in U.S.A. only. Shipping extra on credit card purchases or C.O.D. shipments. Phone orders welcome. Outside U.S.A., shipping additional—write before ordering.

Orion Telescope Center

A Division of Gieseler Electronics

P.O. Box 1158-C 303 Potrero St., Santa Cruz, CA 95060 ☎ (408) 425-1720



Send \$1.00 for our big new catalog of telescopes, accessories, books, space art, and our report "How to Select A Telescope".



Free! Meade Drive

Now, for a limited time, you can purchase a Meade reflecting telescope and receive one of our Model 43 Variable Frequency Electronic Drive Correctors absolutely free!

Just order any Meade motor-drive-equipped reflector—6" through 12½" aperture—during the period of this offer, and we will ship your free drive corrector with the telescope.

The Model 43 Variable Frequency Drive Corrector greatly broadens the observing versatility of your telescope, and includes the following important capabilities:

1. Permits field use of the telescope's electric motor drive, simply by plugging into any standard automobile cigarette lighter.
2. Allows pushbutton "fast" or "slow" control in Right Ascension, for accurate electronic guiding during photographic exposures.
3. Fine tunes the telescope's drive rate to match precisely the lunar, planetary, solar, or sidereal rates.

every Telescope.*

* Purchased separately, the Model 43 Drive Corrector is priced at \$59.95, and we have sold hundreds at that price.

* One Model 43 Drive Corrector will be shipped at no extra charge with the purchase of any of the following Meade reflecting telescopes: 6" Models 591, 628, or 645; 8" Models 826, 856, or 880; 10" Model 1060; 12½" Model 1266. Orders to receive free drive correctors must mention this ad to qualify.



A. 6" Model 591



B. 6" Model 645



C. 8" Model 826



D. 10" Model 1060



E. 8" Model 880

F. 12½" Model 1266

COMPLETE REFLECTING TELESCOPES

Each instrument includes electric motor drive, setting circles, 2 multi-coated eyepieces, 6 x 30mm viewfinder, rotating tube, and many other standard features. See the Meade catalog for full details.

- A. MODEL 591: 6" 1/8 with Motor Drive \$319.50
 B. MODEL 645: 6" 1/5 with Motor Drive 389.95
 C. MODEL 826: 8" 1/6 with Motor Drive 489.95
 Packing charges: 6"-\$15.00; 8"-\$25.00

COMPLETE RESEARCH SERIES TELESCOPES

For the advanced amateur requiring the very finest. Each telescope includes the Research Series equatorial mount with Seal-master ball bearings, worm gear electric drive system, and 6" setting circles; 8 x 50mm viewfinder, giant #680 focuser, 360° tube rotation system.

- D. MODEL 1060: 10" 1/6 with Motor Drive \$1295.00
 E. MODEL 880: 8" 1/6 with Motor Drive 995.00
 F. MODEL 1266: 12½" 1/6 with Motor Drive 1675.00
 Packing charges: 8"-\$50; 10"-\$60; 12½"-\$75. All prices F.O.B. Costa Mesa, Calif.

Optional Accessories: Including camera adapters, photo-guide telescopes, accessory shelf, giant 4¼" viewfinder, drive correctors, manual declination and R.A. controls, leveling screws, and casters are shown on some of the above telescopes.

Research level telescope parts and accessories from America's No. 1 supplier to the serious amateur

RACK-AND-PINION FOCUSERS — Precision metal construction. All 3 models include helical-cut rack and variable-tension adjustment for ultra-smooth focusing without backlash. Universal bases fit all tube sizes. Standard 1 1/4" eyepiece holders. Each focuser is guaranteed to be the finest obtainable in its class.

1 — MODEL 67 — Strong, lightweight design for 4" to 10" telescopes. 2-3/16" travel. An excellent value. **\$19.75 ppd.**

2 — MODEL 640 — A heavy-duty deluxe focuser for 6" to 16" telescopes. Full 3" travel for both visual and photographic applications. **\$35.95 ppd.**

3 — MODEL 680 — Our finest focuser. Accepts both 1 1/4" and 2" eyepieces. Full 3" travel for photo or visual observing with 6" to 16" telescopes. **\$42.95 ppd.**

4 — NEBULAR FILTER — This revolutionary 3-channel filter effectively blocks sodium and mercury emissions from city lights as well as natural airglow, while transmitting 90% of critical visual nebular emissions. Dramatically improves telescope performance visually and photographically. Hermetically sealed, anti-reflection coated, 23mm clear aperture. Threads directly into all Meade 1 1/4" O.D. eyepieces. **\$59.95 ppd.**

5 — PHOTO-VISUAL COLOR FILTERS — Top quality optical glass, dyed-in-the-mass, with excellent spectral homogeneity. Mounted in machined metal cells which thread directly into all our 1 1/4" "Series 1", "Series 2", and "Research-Grade" eyepieces. Filters may be piggybacked. Listed by Wratten No. and color: #8 Light Yellow — #11 Yellow-Green — #12 Yellow — #21 Orange — #23A Light Red — #25A Red — #47 Violet — #58 Green — #80A Blue — Polarizer (30% transmission). Each filter: **\$7.95 ppd.** Set of any 6: **\$44.50 ppd.** Full set of 10: **\$73.50 ppd.**

6 — VARIPAK DRIVE CORRECTOR — Model 43 — A quality electronic guiding unit with Supercompact (2" x 3" x 4") design. Fast-slow pushbuttons mounted on the power pack. Variable control for lunar, planetary, sidereal rates. Operates from 12 volts D.C., plugs into standard auto cigarette lighter. The 12-watt output is sufficient for most telescopes to 14" aperture. **\$59.95 ppd.**

7 — VARIGUIDE DRIVE CORRECTORS — The finest R.A. drive correctors available. Each unit includes aircraft-type joystick controller for continuously variable correction rates, not just "ON-OFF". Models 40 and 41 may be used with any motor-drive-equipped telescope rated up to 12 watts, including most commercial telescopes to 14" aperture.

Model 40 — Operates from 12 volts D.C. Control box includes variable center-frequency settings for lunar, planetary, sidereal rates. **\$89.95 ppd.**
Model 41 — Identical to Model 40, but operates from either 12 volts D.C. or 115 volts A.C./60Hz. **\$119.95 ppd.**

8 — VARIGUIDE DUAL-AXIS CORRECTOR SYSTEMS — For the advanced astro-photographer. Universal joystick controllers permit continuously variable correction rates simultaneously on both telescope axes. Each unit includes electronic control systems for both R.A. and Declination, along with all required mounting hardware. Models are available to fit Meade 600- and 800-Series reflectors and for the Celestron 5 and 8, as noted. After 15 minutes' installation, you will be using the most sophisticated and precise guiding system ever offered the serious amateur.

Model 47M — Attaches to Meade 600- and 800-Series reflectors. Operates from either 12 volts D.C. or 115 volts A.C./60Hz. **\$215.00 ppd.**

Model 47C — Attaches directly to Celestron 5" and 8" telescopes. Operates from either 12 volts D.C. or 115 volts A.C./60Hz. **\$195.00 ppd.**

New! Multi-Coated Series 2 and Research-Grade Eyepieces

Manufactured to entirely new Meade designs, these Series 2 eyepieces are a significant advance in eyepiece technology. Utilizing modern high-density optical glasses, each eyepiece has been computer optimized to yield the highest level of optical performance obtainable within its design class. Air-to-glass surfaces on all Series 2 and Research-Grade eyepieces are Multi-Coated for maximum light transmission and image contrast. All 1 1/4" barrels are threaded for Meade filters.

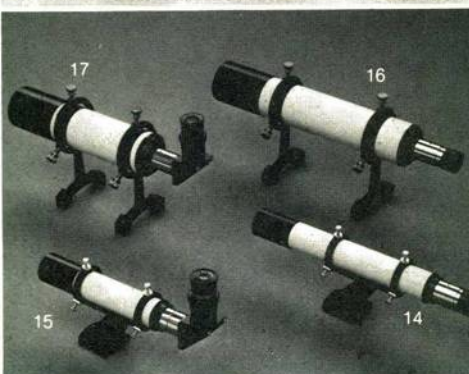
9 — SERIES 2 MODIFIED ACHROMATIC EYEPIECES (1 1/4" O.D.; MULTI-COATED) — Fine 3-element systems, precisely corrected for chromatic and spherical aberrations. Guaranteed to be the finest eyepieces obtainable for under \$25.00. FOCAL LENGTHS: MA 6, 9, 12, 25mm and 40mm Wide-Field... each **\$19.50 ppd.**

10 — MODIFIED ACHROMATIC 40mm EXTRA-WIDE-FIELD EYEPIECE (1 1/4" O.D.; MULTI-COATED) — Yields widest field obtainable in 1 1/4" O.D. Enlarged field lens and special field-flattening optics with long eye relief. **\$24.75 ppd.**

11 — SERIES 2 ORTHOSCOPIC EYEPIECES (1 1/4" or .965" O.D.; MULTI-COATED; PARFOCAL) — The excellent 4-element high resolution optics of these oculars are all that the majority of serious amateurs will ever require. Razor sharp 45° fields. Both the 1 1/4" and .965" O.D. sets are accurately parfocalized. FOCAL LENGTHS: OR 4, 6, 9, 12.5, 18, and 25mm... each **\$27.95 ppd.**

12 — RESEARCH-GRADE ORTHOSCOPIC EYEPIECES (1 1/4" O.D.; MULTI-COATED; PARFOCAL) — The largest selling premium-quality eyepieces in the world, universally acclaimed to be the finest eyepieces obtainable. These 4-element systems are unsurpassed in color correction, resolution, and flatness of field. 45° field. Accurately parfocalized. FOCAL LENGTHS: OR 4, 7, 10.5, 16.8, 28mm... each **\$38.95 ppd.**

13 — RESEARCH-GRADE ERFL EYEPIECES (1 1/4" O.D.; MULTI-COATED; PARFOCAL) — For breathtaking wide-angle observations. 65° to 75° fields, parfocalized with our Research-Grade Orthoscopics. FOCAL LENGTHS: ER 12.4, 15.5, 20mm... each **\$44.50 ppd.**



VIEWFINDERS — Each includes coated, achromatic objective lens and crosshair eyepiece:

14 — 6 x 30mm — Fine 4" wide-field finder. Thousands now in use. 2-ring bracket included, fits all tubes 6" to 12 1/2". **\$21.95 ppd.**

15 — 6 x 30mm RIGHT-ANGLE — As in (14) but with diagonal prism for convenient right-angle observations. Bracket included. **\$27.95 ppd.**

16 — 8 x 50mm — 5" field and large 50mm aperture. Sharp, brilliant images. **\$33.95 ppd.** Brackets: **\$7.95/pr. ppd.**

17 — 8 x 50mm RIGHT-ANGLE — As in (16) but with diagonal prism, for right-angle viewing. **\$39.95 ppd.** Brackets: **\$7.95/pr. ppd.**

18 — ERFL 32mm EYEPIECE (2" O.D.) — Sophisticated 5-element optical system. Wide, flat 65° field. The ultimate in rich field performance, for 2" focusers. **\$94.50 ppd.**

19 — KELLNER 60mm EYEPIECE (2" O.D.) — Low power, long eye relief. Ideal for deep-space observations. Fully coated. **\$49.50 ppd.**

20 — DELUXE CAMERA ADAPTERS — Adapt your camera to telescope focuser instantly. Individually machined from solid bar aluminum and brass. All units permit both eyepiece-projection and first (prime) focus photography. Specify either 1 1/4" or .965" focuser. All 1 1/4" units are threaded for our filters. Pentax, Yashica, Mamiya... **\$18.95 ppd.** — Nikon, Canon, Minolta, Pentax K, Exakta, Konica, Olympus OM-1, OM-2... **\$26.75 ppd.**

21 — 2X TELENEGATIVE AMPLIFIER (1 1/4" O.D.; MULTI-COATED) — Model 122: Warranted without qualification to be the world's finest Barlow lens. Full 26mm clear aperture. Multi-Coated, with virtually flawless optical corrections at all photo-visual wavelengths. Produces optimum performance on telescopes of any focal ratio... **\$29.50 ppd.** Model 131: Per Model 122, but for .965" focusers; 18mm clear aperture, Multi-Coated... **\$24.50 ppd.**

22 — 2X-3X VARIABLE TELENEGATIVE AMPLIFIER (1 1/4" O.D.; MULTI-COATED) — Model 127: Manufactured to the same research standards as the Model 122 above, but mounted in a precisely machined sliding cell, to permit variable power settings between 2X and 3X. Engraved scale indicates power. Multi-Coated... **\$36.50 ppd.**

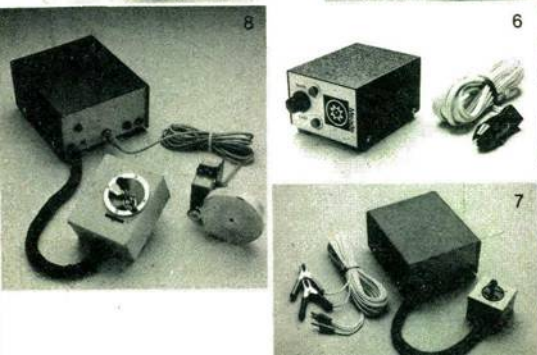
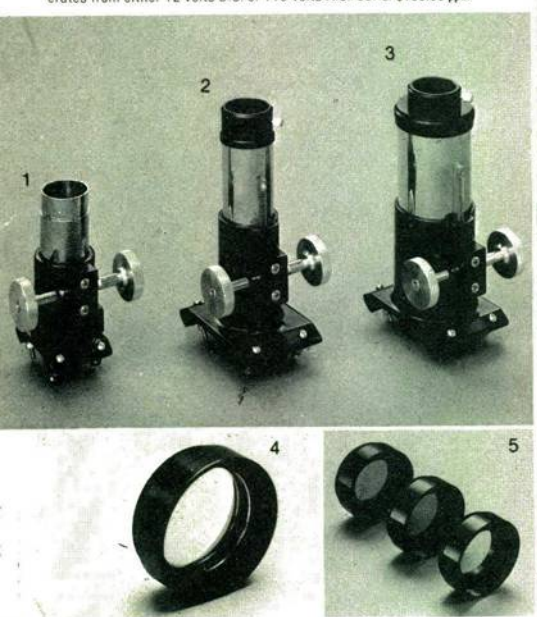
23, 24 — ACCESSORY CASES — Rugged polyethylene, for dust-free protection of eyepieces, filters, Barlows, etc. Die-cut foam lining. Model 51: 7" x 8 1/2"... **\$8.95 ppd.** Model 54: 8" x 12"... **\$12.95 ppd.**

25 — ILLUMINATED RETICLE GUIDING EYEPIECE (1 1/4" or .965" O.D.) — New phosphorescent etched double-line reticle permits line illumination from dim to extremely bright. Remote brightness control and 6 ft. cable. Modified Achromatic 12mm optical system. Precisely focusable reticle. Complete... **\$47.50 ppd.**

Micrometer Reticle: Full-field scale for accurate measurements of double star separations, planetary angular diameters, etc. Interchanges with standard 4-line reticle... **\$14.95 ppd.**

26 — ERRECTING PRISMS — Fully coated Porro prisms, for terrestrial observations with astronomical telescopes. 1 1/4" O.D.... **\$32.95 ppd.** — .965" O.D.... **\$19.95 ppd.**

27 — DIAGONAL PRISMS — Quality right angle prisms, fully coated. 1 1/4" O.D.... **\$19.95 ppd.** — .965" O.D.... **\$14.95 ppd.**

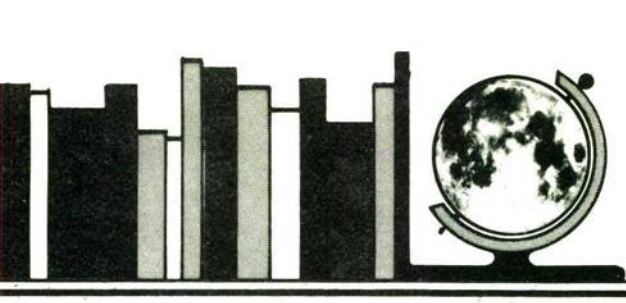


Mail Orders: Write us your requirements — or use the order form which accompanies our catalog.
Telephone Orders: Accepted with payment either C.O.D. or credit card (we do not accept collect calls).
Payment: Personal or bank check, money order, or credit card (VISA or Master Charge).
Shipment: All orders are processed for shipment within 24 hours.
California Residents: Add 6% Sales Tax. **Canadian Orders:** Add 10% to cover priority mail charges.
Foreign Orders (Outside North America): Add 20% to cover Air Parcel Post charges. Payment must be made by bank check in US \$.
General Catalog 79-C — \$2.00 (Outside North America \$3.00 for Air Mail). (Catalog free with any order.)

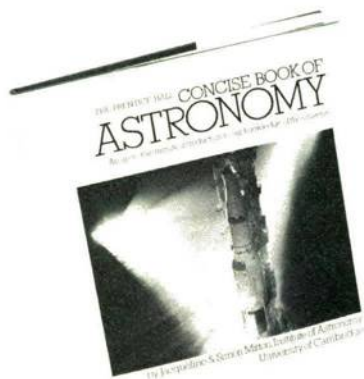
Card No. _____ Expiration Date _____ / _____ / _____
Name _____
Address _____
City _____ State _____ Zip _____

Meade Instruments Corporation 721 W. 16th Street, Costa Mesa, Calif. 92627 (714) 646-9281

© 1979 Meade Instruments Corp. TM Series 2, Research-Grade, Fiberlite, VariGuide, and VariPak are trademarks of Meade Instruments Corp.



ASTRONOMY *bookshelf*



CONCISE BOOK OF ASTRONOMY

(by Jacqueline and Simon Mitton)

Although written with young people in mind, this colorfully illustrated book will be appreciated fully by any newcomer to the world of astronomy. The Mittons present the grandeur of the subject, stressing in particular the many profound and revolutionary discoveries of the past two decades. Anyone of any age will find much browsing and reading pleasure, along with a simple guide to the seasonal constellations. Hardback, 96 pages.

\$11.50

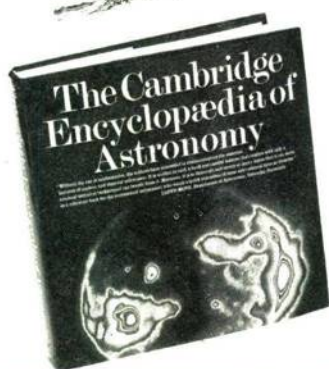


ASTRONOMY: THE COSMIC JOURNEY (by William K. Hartmann)

Possibly the finest, one-volume survey of modern astronomy is now available! Profusely and excitingly illustrated, Hartmann's book assumes no knowledge of math beyond arithmetic, and conveys to the interested layman the wonder and drama of astronomical knowledge. Building on fundamental principles clearly laid out, he presents the awe-inspiring contemporary view of the universe.

Fully indexed, with a glossary and extensive bibliography for further reading.

\$17.75



The Cambridge Encyclopaedia of Astronomy

An authoritative, up-to-date survey of every aspect of modern astronomy: our solar system, stars and how they're born, change and die; galaxies; the very latest about the history of our universe.

Completely indexed for quick, efficient reference, and illustrated with brilliant color photographs, charts, diagrams and historical pictures. Hardcover.

\$36.50



To order use form bound into this magazine.

U.S. Observatories: a Directory and Travel Guide by H.T. Kirby-Smith

Just introduced, this handy companion to your travels will help you find and tour the many observatories in the country. Paperback. **\$7.50**

Seasonal Star Charts

Printed on heavy coated paper for extra durability, the star charts in this handy atlas lie flat when opened, ready for use. **\$6.75**

Newton's Deep Sky Objects

Jack Newton, experienced amateur astronomer and astrophotographer, has produced an illustrated guidebook featuring all the Messier objects and more! Designed to help you find, observe and photograph the best of the deep-sky wonders. **\$12.50**

Reading List

The Red Limit by Timothy Ferris

The thrilling story of our quest to discover the limits of the universe has never before been told in such a fascinating way. Hardback, **\$10.50**.

Star Names: Their Lore and Meaning by Richard Allen

One of our best-sellers, this indispensable work tells you all about the folklore and legends of stars and constellations. Paperback. **\$6.00**

The Astronomical Directory by James Gall

Tells you who to contact and where to go to find local astronomy enthusiasts and planetariums in the U.S., Canada and the world. 144 pages, paperback. **\$7.25**

Starflight and Other Improbabilities

A fascinating exploration of the possible — Ben Bova assembles scientific theories, established knowns, unknowns and maybes to bridge the gap between theory and practice. Written for the younger reader, 125 pages, hardcover. **\$4.75**

New Concise Atlas of the Universe by Patrick Moore

Get 4 atlases in 1 in this new, revised edition! Separate sections cover Earth from space, the moon, the solar system, the stars. Easy-to-understand text includes a catalog of stellar objects and glossary. Nearly 1000 photographs, maps and diagrams (400 in full color). Hardcover. **\$31.00**



GAZER'S GAZETTE

The Moon: Mountains, Basins, and Scarps

Some night when the Moon is either a day past first or a day before last quarter, take out your telescope and aim it at the Moon. In the northern part of the disk, near the line between day and night, you'll see a long, curved rampart standing out high over the surrounding terrain.

This is the lunar Apennine mountain range, a great chain of peaks and jumbled terrain stretching some 500 miles north and east from the crater Eratosthenes. These lofty mountains soar 15,000 feet or more over the flat mare surface to the west, and are part of a vast broken ring of mountain ranges circling Mare Imbrium.

Most lunar geologists think that the Apennines, along with the Carpathian, Caucasus, Alps, and Jura ranges, form what is left of a giant crater ring surrounding the site of the "Imbrium event." This event, which excavated the basin now filled by Mare Imbrium, was no less than the impact of a small asteroid (perhaps 100 miles in diameter) some 3.9 to 4 billion years ago. The impact of this massive chunk of rock blasted out a circular depression, heaving up a ring of shattered debris around the area.

No Tectonic Mountains

In this, the Apennines are thoroughly typical of lunar mountains in general. No slow, inexorable pressures of tectonic movement or drifting continents created these shapes, but rather sudden and violent explosions.

Even the isolated mountains you see poking up here and there in the maria were formed this way. (Mare Imbrium has several fine examples: Pico, Piton, the Teneriffe and Straight Ranges, the Spitzbergens and so on.) All of these

are suspected to be merely the remnants of a large circular ring, created at impact and totally obliterated — except for the highest peaks — when the mare basalts flowed out to fill the basin.

Mare Serenitatis

Leaving Mare Imbrium for the moment, let's look at a couple of other ranges and see what can be seen of them. Immediately to the east of Imbrium is another, smaller, mare that's also roughly circular, Mare Serenitatis.

If you look around the rim of the mare, you see land regions that are raised above the mare's dark surface, but nothing that stands out like the Apennines do. In the southwest are the lowly Haemus Mountains, while on the eastern side spreads the Taurus range which has peaks of about 10,000 feet. On the north and south of the mare, the rim-wall disappears and it looks like mare material flowed out and filled in Lacus Somniorum (near the crater Posidonius) and Mare Tranquillitatis (to the south).

Since Mare Serenitatis is circular and because studies of spacecraft in lunar orbit have clearly established the existence of large amounts of heavy material in a basin under the mare surface, it's a pretty safe bet that it too, like Imbrium, is a flooded impact basin, altered by later cratering.

But as you can plainly see, the surrounding mountain ranges aren't very impressive, though isolated peaks in the Caucasus reach to 18,000 feet. While mare rocks returned from here lead scientists to believe that the Serenitatis basalts are younger than the Imbrium ones, the more subdued appearance of the region may indicate

that its *basin* was formed prior to the Imbrium event.

Fresh Basins

What might a fresh impact basin look like, before its features were flooded and destroyed?

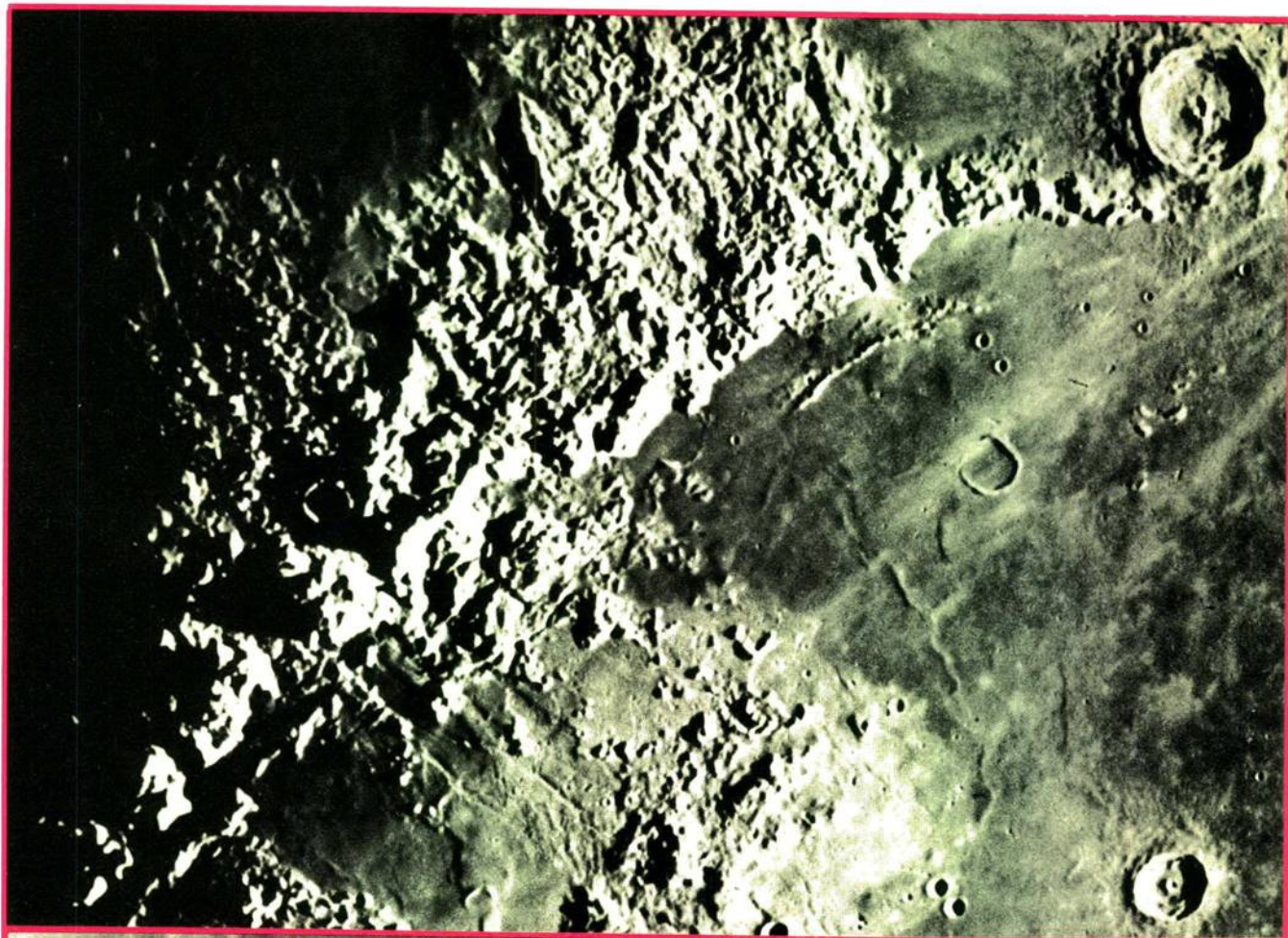
Unfortunately, the best example of such a structure is almost totally invisible to a terrestrial viewer. It is Mare Orientale, centered about 5° beyond the Moon's western limb. Due to inequalities in the Moon's motion, every now and then you can peek a little "around the corner" and catch sight of its outer walls. These were discovered long ago and named the Rook and Cordillera Mountains, but their true shape and grandeur can be appreciated only in photos taken from lunar orbit.

Are earthlings then out of luck? By no means; follow the dark blotches of the maria to the south of Mare Serenitatis across Tranquillitatis. Here, to the east of the three grand craters (Theophilus, Cyrillus, and Catharina) lies the visible hemisphere's well-preserved "original" basin — Mare Nectaris.

Mare Nectaris

It's best to catch this area at local morning, but local evening will do almost as well. At the west edge of the mare surface there may have been a range of mountain peaks, but the later arrival of Theophilus & Co. interfered and obliterated it. On the east side of the mare rise the Pyrenees. On the south there is little to trace in the terrain (besides the partly flooded crater Fracastorius) as it climbs into the Southern Highlands.

But look west of the mare, in the uplands beyond the immediate area. Here, if it's morning, you'll see a long,



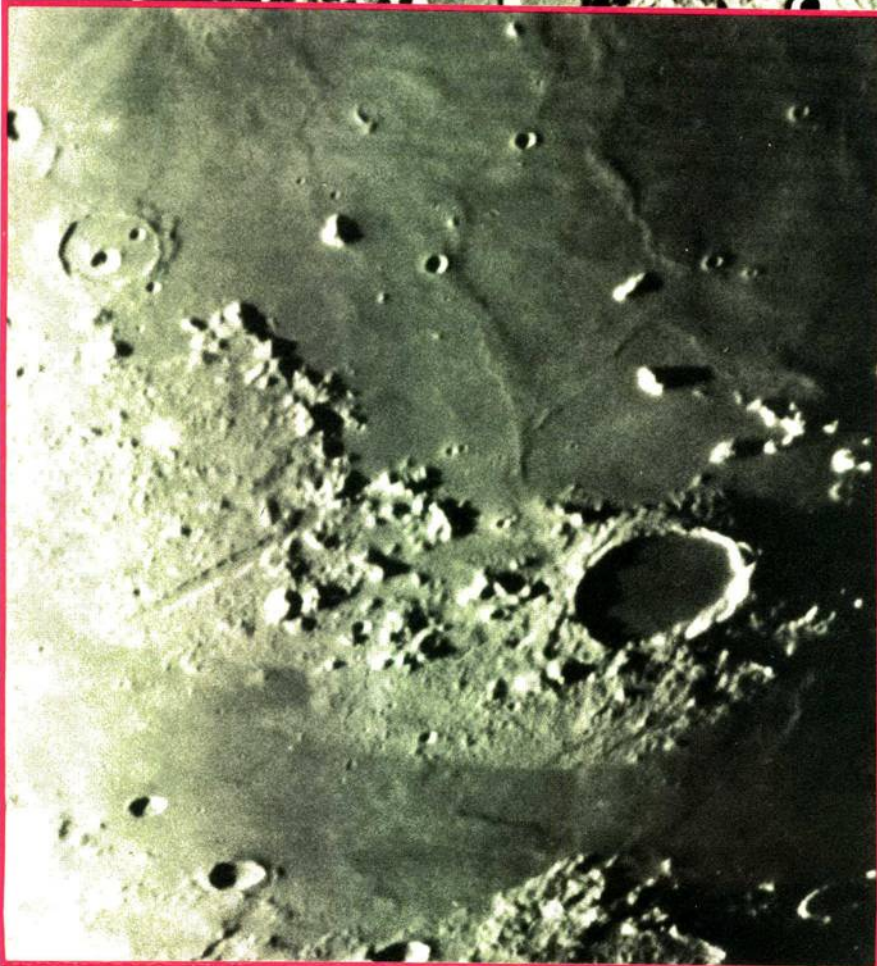
Above: The lunar Apennine chain of mountains stands out clearly in the setting Sun. At the upper right is Eratosthenes. Lick Observatory photo. **Left:** The Alpine Valley cuts through the lunar Alps, while isolated peaks thrust up out of the mare surface; Plato is the large crater at right center. Tim Tomljanovich photo. (Here and throughout, all photos have south at the top.)

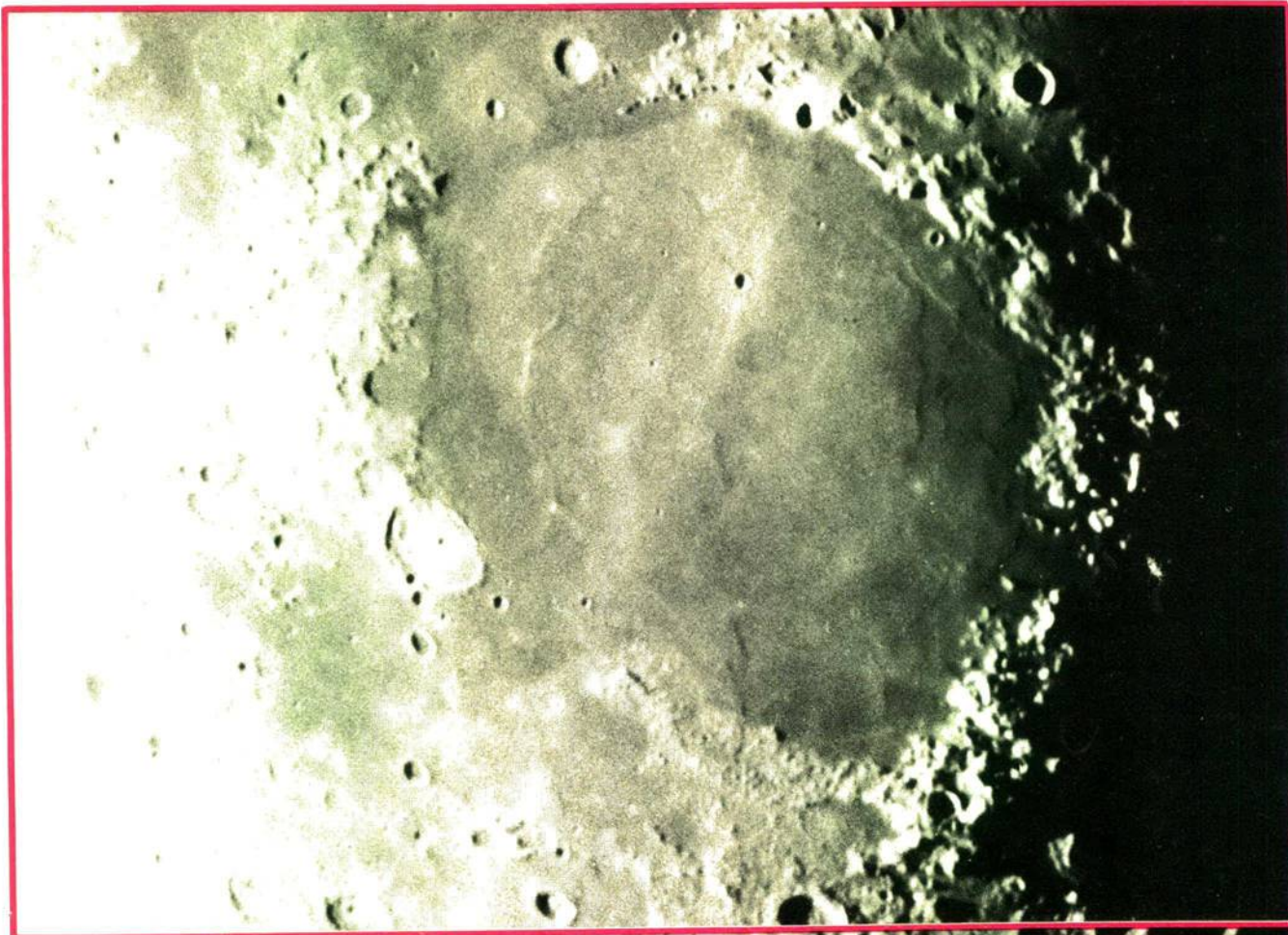
brightly lit ridge curving through the Highlands and paralleling the distant mare shore. This is the Altai Scarp, a 10,000 to 13,000 foot high chain of ridges that starts indistinctly to the northwest of the mare and arcs around to the south, apparently ending at the crater Piccolomini. However, if the lighting's right (local evening works best for this), you can trace the scarp around the south of the mare and up the eastern side. Under best conditions, this unnamed scarp in the east will appear almost as distinct as its companion range in the west.

Some observers see an intermediate ring, much ruined, lying between the mare and the Altai Scarp. If it exists, there's very little of it left, though you may be seeing the faint traces of a counterpart to the Pyrenees on the eastern side.

What to Look For

From the example of Maria Orientale, Imbrium, Nectaris, and



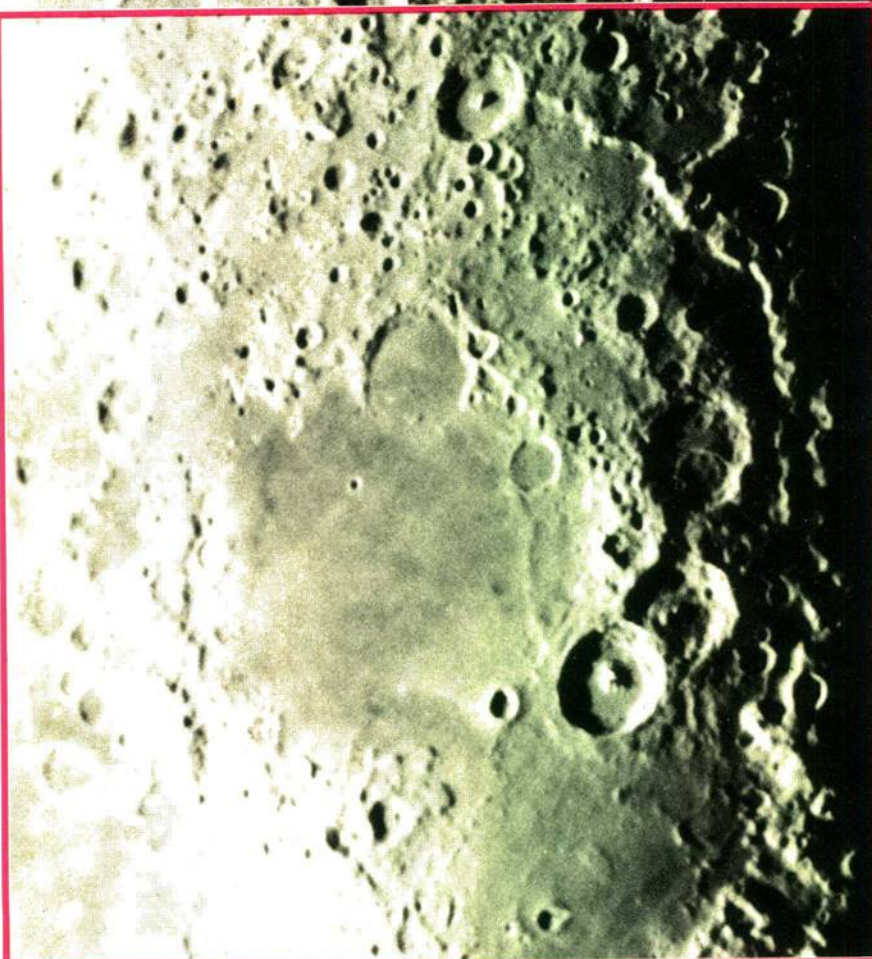


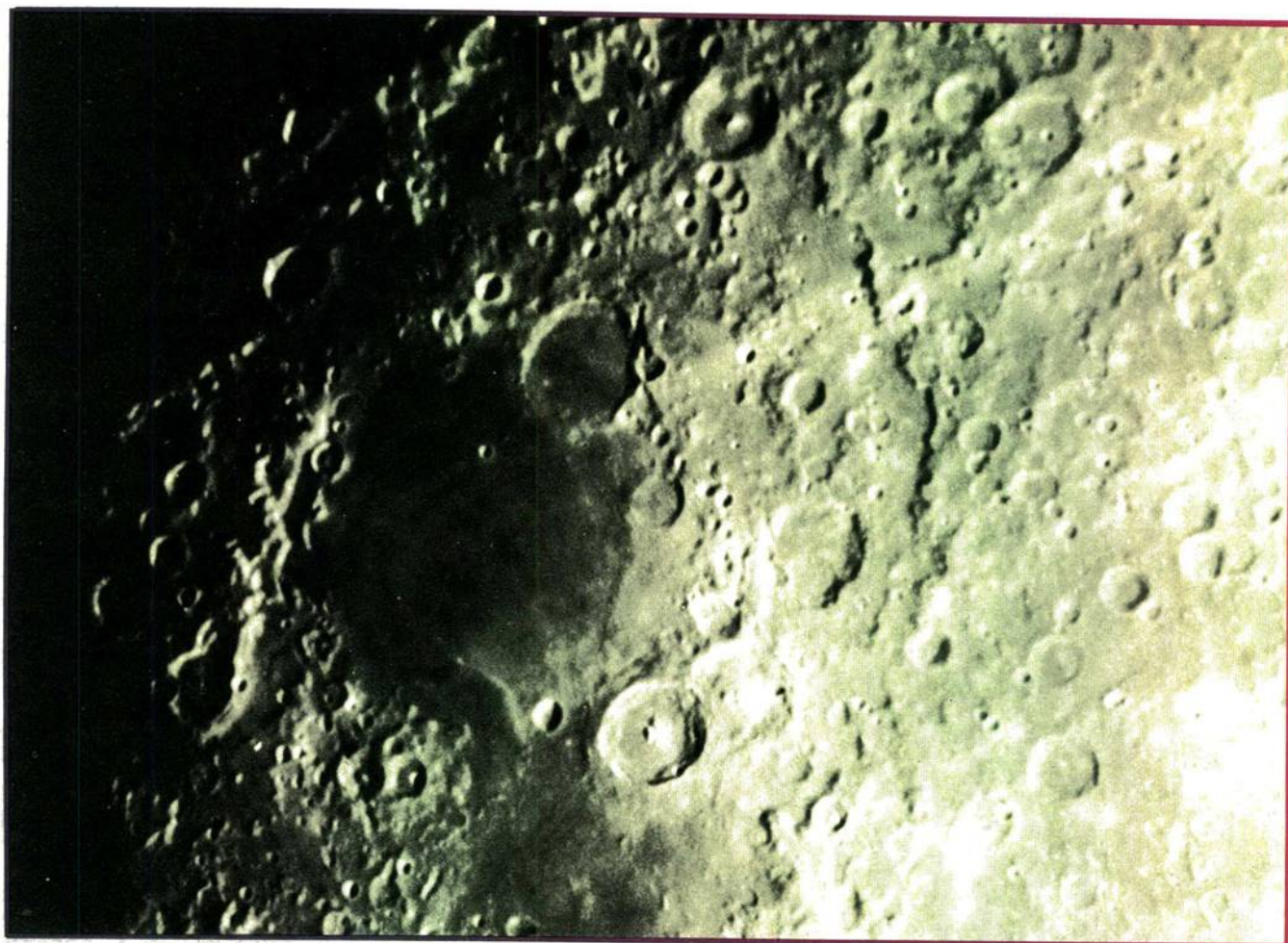
Above: Mare Serenitatis and the mountains surrounding it are seen here in local morning light. Right: The Mare Nectaris basin, Altai Scarp, and environs; how many scarps can you find? Both photos by Jean Dragesco.

other relatively fresh basins, it seems the scar left by an asteroid-size impact resembles a giant bull's eye of fractured rocks. There is a large, shallow main basin surrounded by two, three, or even four up-tilted scarps, concentric around the site. Some time after the impact, lava oozes out along the concentric faults and fills in part or all of the basin.

Up to now, we've been looking at the mountains just as single features; let's look a little closer and see what their shape and topography can tell us.

Return for a moment to Mare Imbrium and the Apennines. When the Apennines are seen by grazing light, their "badlands" characteristics show up very well. The whole area to the east of the rampart has a northwest to southeast grooved or braided texture which continues well beyond the actual mountainous region. (Look to the south of the Haemus Mountains where you'll see a tissue of lineations.) One interpretation sees these as scarps left by flying material thrown out of the basin-to-be as it was formed;





Again Mare Nectaris, but this time under evening illumination. This area well repays observation at all times of the lunar day. Jiri Bunata photo.

another theory claims they're lines of weakened rock, shattered and faulted by the impact. Both effects may well have happened.

The Lunar Alps

Moving north to the Alps, we find other curiosities. In this area, there are no distinct lineations, but as if to make up for it, there's a magnificent rift valley cutting through the 10,000 foot high Alps into Mare Frigoris to the north. Called the Alpine Valley, naturally, this 80 mile long groove has a thin, sinuous rille down the middle of its flat floor. Detecting the rille is a real test of both your telescope (use a large aperture) and the seeing conditions (pick the best nights!).

Continuing around the north edge of Mare Imbrium past dark-bottomed Plato, you enter the Jura Mountains. Here the loftiest altitudes (about equal to the Apennines) are met where the impact that gouged out Sinus Iridum piled up rocks on top of those from the Imbrium impact. Later, the mare basalts breached the southeastern wall of Sinus Iridum and made the large crater into what its Latin name calls it — a bay.

The Serenitatis-circling mountains show very little structure (apart from the Haemus lineations). The Taurus area is heavily cratered and the mare has inundated the shore to modify craters like Le Monnier and Posidonius. (Apollo 17 landed here in a "fjord," on mare material but well into the mountains.) To the northwest, what little structure the Caucasus Mountains have is likely dominated by Imbrium sculpturing.

Find That Scarp...

What details can we discern in the Altai Scarp region? Although there appears to be little lineation, perhaps this should be expected if the Nectaris basin is old; later cratering around it in the Highlands would have destroyed the traces.

It's fun prowling around this area because the tangle of landforms is so complicated you never know just what'll catch your eye next. Given the general concentric trend of scarps, see how many you can find. And remember that you'll have to look under many different aspects of lighting, for what stands out clearly at one time of "day" may be invisible later or earlier.

Do lunar mountains ever exist totally unconnected with the maria? They do, but they're hard to find and appreciate. Since the dominant force shaping the lunar surface has been

impact, it's reasonable to go looking for these peaks in areas where cratering has been heavy. Just such a region is the Southern Highlands (see Gazer's Gazette in the June 1979 *ASTRONOMY*). The Moon's highest peaks are found in the Leibnitz Mountains on the southern limb. They don't appear very impressive because you see them solely in profile, but they're about 6 miles high.

Part of the difficulty in observing peaks like these is a perceptual one: mountains near a flat surface (such as a mare) make a strong impression, but those which look like just another peak among many simply don't knock you over at first sight. It isn't until you've spent many hours at the eyepiece, wandering over the Moon's face, that you begin to appreciate the stupendous variety of forms here.

This has been only the shortest of introductions; you'll have to make the full tour on your own. And that's as it should be, for everyone, in one sense, has to discover his or her own Moon. Each lunar observer soon finds particular areas or features that fascinate and intrigue, the ones you return to again and again, perhaps for reasons you can't even figure out. But then who needs reasons to justify such fun as exploring the Moon with a telescope, anyway? 🌙

— Robert Burnham

“Forget about that trip to the moon...”*

☐ THE REALM OF THE TERRESTRIAL PLANETS

Zdenek Kopal, *University of Manchester*

* “Forget about that trip to the moon: you could find nothing more than you’ll find described in a single, sixty page, chapter of this up-to-the-minute *tour de force* of a book!”

—*Physics Education*

“Kopal presents in vivid detail an up-to-date, factual description of the terrestrial planets. . . . Avoiding excessive use of technical formulas, the author presents a nicely readable narrative. Recommended to the interested generalist.”

—*Library Journal*

“... well illustrated. . . . good solid scientific information and explanations of how our present ideas were obtained and what problems remain to be solved.”

—*Choice*

(Rights: U.S. and Canada)

(0 470 26688-0) 1979 223 pp. \$19.95

☐ PROJECTS AND DEMONSTRATIONS IN ASTRONOMY

Donald Tattersfield, *North Gloucestershire College of Technology*

Recreate the mystery and majesty of the universe with this exciting approach to astronomy based on 61 indoor projects you can launch with a minimum of instruments. Tattersfield supplies a wealth of project background (theory and empirical data). Fully illustrated with descriptive line drawings and photographs. Includes project solutions and 16 detailed mathematical appendices. (Rights: U.S. and Canada)

(0 470 26715-1) 1979 331 pp. \$27.50

☐ FOUNDATIONS OF ASTRONOMY

From Big Bang to Black Holes

Richard Knox, *editor of Nuclear Engineering International*

Anyone with an interest in the stars will experience the inevitable excitement of man’s space explorations with this unique, fully illustrated book. Examines the ways various bodies of the universe function and interact, and presents some advanced astronomical theory and astrophysics in terms requiring only a general scientific background—or just a keen interest—to understand. Includes instructions for making a telescope at minimal cost. (Rights: U.S.)

(0 470 26638-4) 1979 184 pp. \$10.95

☐ PLANETARY GEOLOGY

John Guest, *University College, London*, Paul Butterworth, John Murray, & William O’Donnell

This new science—born July 20, 1969 when man stepped onto the moon—is set forth with the intriguing data and wealth of photographs from explorations of our planetary neighbors. CONTENTS: The Earth and Other Planets. Cosmic Clues. First Step: The Moon. Red Sands, Red Skies: Mars. Flyby: Mercury. Hothouse: Venus. The Future. Appendix. Glossary. Further Reading. (Rights: U.S.)

(0 470 26887-5) January 1980
approx. 208 pp. \$19.95 (tent.)

☐ MATHEMATICAL ASTRONOMY WITH A POCKET CALCULATOR

Aubrey Jones

A practical new guide—becoming immensely popular and transforming the mathematics of astronomy from a chore to a pleasure. Shows how simple to complex astronomical problems are solved accurately—almost at the push of a button—using the electronic calculator. Calculate everything from Local Sidereal Time for any geographical location to ephemerides for binary stars and comets. Detailed examples and tables. 57 fully documented programs for key and magnetic card programmable calculators. (Rights: U.S.)

(0 470 26552-3) 1979 254 pp. \$15.95

☐ POSITIONAL ASTRONOMY AND ASTRO-NAVIGATION MADE EASY

A New Approach Using the Pocket Calculator

H.R. Mills, with a foreword by D. McNally,
University of London Observatory

“... Up to now there have been no books dealing with work of this kind. . . . Mr. Mills has filled this gap in the literature. . . . should run to many future editions.”

—*New Scientist*

“A well presented and detailed book containing a wealth of useful information. . . .”

—*Yachting World*

(Rights: U.S.)

(0 470 99324-3) 1978 267 pp. \$24.95

☐ USING THE TELESCOPE

A Handbook for Astronomers

J. Hedley Robinson, *British Astronomical Association*

Robinson’s fifty plus years have gone into the making of this essential companion for the sky gazer. Provides invaluable instruction and advice on all aspects of telescope care and use. Includes the correct observational techniques for all celestial bodies likely to be observed and particularly helpful guidance in such areas as astrophotography. (Rights: U.S.)

(0 470 26514-0) 1979 112 pp. \$9.95

Indicate the book(s) which you wish to examine free for thirty days and mail this ad to:



Dept. 313 A-32

HALSTED PRESS

a division of John Wiley & Sons, Inc.
605 Third Ave., New York, N.Y. 10016

☐ PAYMENT ENCLOSED + applicable sales tax. Halsted pays postage/handling. NOTE: We usually ship within 10 days. If payment accompanies order and shipment cannot be made within 90 days, full payment will be refunded. Foreign payment must be made in U.S. currency, by U.S. bank draft, international money order or UNESCO coupons.

☐ BILL ME + postage/handling. If order totals \$75 or more 25% partial payment must be enclosed.

NAME _____

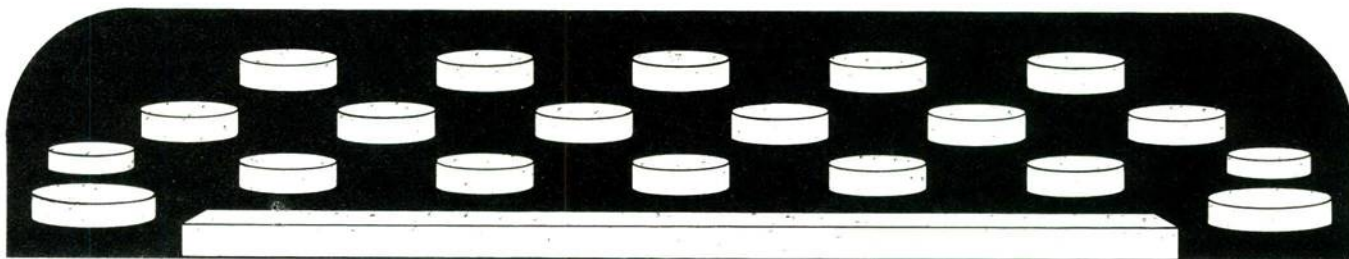
ADDRESS _____

CITY _____ STATE _____ ZIP _____

Prices subject to change without notice, slightly higher in Canada.

IN CANADA: John Wiley & Sons Canada, Ltd., 22 Worcester Road,
Rexdale, Ontario 313 0-7253-67

Book with Halsted Press



IN FOCUS

Sir / Regarding the deluge of vituperation descending on the head of H. Halvorsen for the article "I'm Not Worried" (Forum, July 1979)..., ignoring for the moment the sentiments of "He's just a shortsighted spoilsport," "Screw the world," "We want our energy," and "What are you willing to take in exchange for your global soul?" expressed by the three correspondents (In Focus, September 1979), I, for one, am willing to back SPS to the hilt as long as I am assured that techno-messianic zealots like Halbert, Merkey, and Henson are on the first ship up.

Of course should they try to return, I will insist that they be shot down.

Gael Baudino
Los Angeles, CA

Sir / I feel compelled to enter the fray pitting H. Halvorsen against his critics, W. Merkey, *et al.*, on the subject of Solar Powered Satellites (SPS). I do not seek to defend Mr. Halvorsen; he undoubtedly got what he deserved. When one pontificates with statistics — accurate or not — the critics will descend like vultures with a profusion of counterstatistics.

Mr. Halvorsen pointed out what he considered to be several major — even fatal — flaws in the SPS concept. Mr. Merkey rebutted at length on a point-by-point basis, while Ms. Henson ably assisted him and Mr. Halbert offered spiritual support. What were the critics saying? We were told that materials, techniques, and costs pose no problem, since we are bound to overcome any obstacles. We were told not to grieve over the demise of Earth-based astronomy and communications; there were confident predictions that the communications could be reconstructed and that great new observatories in space would more than replace our scientific loss. We were even told not to worry about restrictive international laws, for they can be unilaterally abrogated; nor to worry about hostile attacks, for they can be repulsed with particle-beam super-weapons. All in all, we were told to sit back and have complete faith in a marvelous technological system which

is on the verge of delivering a utopian nirvana in space.

I will not argue that we may all too soon desperately need the amounts of energy that an SPS can generate. I will also not argue that we can build an SPS; for the sake of debate I will accept the unproven assumption that such construction will become feasible. However, I would like to offer one novel question amidst all the bantering: Do we truly want the SPS? And I would like to offer a novel answer: No!

The United States has a ravenous appetite for energy. We consume the equivalent of over 300 million BTU per capita every year. Such voracious consumption is unjustifiable and inexcusable. It is time for the sane voices in our society to shout: "Enough!"

We do not need the SPS, regardless of whether it can be built. We need to learn how to live intelligently, within reasonable limits, and in harmony with our planet. We do not need to go blasting off into space like some technologically swashbuckling version of *Star Wars* to leave our corruptive imprint on the rest of the universe.

What particularly disturbs me about the critics of Mr. Halvorsen is their apparently unbounded faith in the power of technology and the omnipotence of men. It takes a very gross and crude arrogance to blithely dismiss all Earth-based astronomy as so much scrap iron and glass and to speak of the laws of the international community as something to be conveniently violated whenever we want to erect another super-tinkertoy. I find such arrogance frightening. I can not join with those who roar in glee as the mindless technocratic juggernaut runs wildly out of control.

I am a romantic; I love the lure of space, and I tearfully celebrate each new milestone of our explorations. I look forward to the ever-increasing potential of space-based astronomy. I look forward to man reaching out to the stars.

But I am opposed to man running amuck in space as he has so disastrously done over the face of planet Earth. I am opposed to unneeded "white

elephants" like the SPS, especially when its most important purpose seems to be as a financial justification for the extravagant, hopelessly unrealistic ambitions and pipe dreams of those recklessly advocating crash programs to construct utopian space colonies. Like any romantic, I too dream of utopia. But I also know that painful truth — utopia is that vague mist that forever lies just beyond our grasp.

Michael W. McGuire
Placentia, CA

Sir / In response to the letters from readers in the In Focus section of the September issue of ASTRONOMY, I

Behind the Scenes

**100 Pages
and
100,000 Readers**

ASTRONOMY's growth in the last few issues has amazed all of us here. Beginning in June, when we increased ASTRONOMY from 80 pages to 84, the growth of the magazine seems to have come by leaps and bounds. Not only are we now running more pages on a regular basis than ever before — a full 100 in this issue — but also our circulation now exceeds 100,000 (this fact was first announced in our advertisement in the September issue of *Scientific American*). We realize 100,000 is just a number like any other number, but it's an important psychological goal: It makes us feel we're doing something right.

This extraordinary summer brought us three fantastic planetary flybys, meaning, of course, extra work for everyone getting the story of each flyby out to you as quickly as possible. Monthly magazine deadlines probably don't mean very much to you, but remember that your issue of ASTRONOMY spends 12 to 21 days in the mail.

It was, for example, quite a crunch to get pictures and the article from the July 8 Voyager 2 flyby into the September issue — I arrived back in Milwaukee on the 13th, wrote the article, chose the pictures, we set the type, did the paste-up, and sent it out to our "film house" on the 20th; they delivered "final films" to the printer on the 28th, and we were on press the 2nd and 3rd of August. 100,000 copies were bound, trimmed,

don't believe that very many amateurs could afford the trip to space that was likened to a vacation in Australia. I couldn't even afford bus fare for me and my 4 1/4" reflector from Kansas to Canada for the total solar eclipse of February 1979.

Today, I can take my telescope out whenever I want to on a moment's notice. Would I be able to fly to an orbiting observation platform whenever I wanted to? It seems very doubtful.

Fred Gatschet
Manhattan, KS

Sir / "The Grand Adventure" and the related supplements in your March 1979 issue were commendable for encouraging support for the U.S. space program. However, support must be initiated where it is most necessary — among people with little or no scientific interest — and in terms of realized and potential benefits understandable and applicable to the nonscientific community.

Space exploration too easily falls into a category of "glamorous but unimportant" to those who are not aware of its contributions. When the initial drama wears off, interest and

support die. People need to be made aware of the benefits and goals of universal exploration. Once cognizant of its significance, voters can knowledgeably support legislation to promote our space program.

M.A. Yvon
Southfield, MI

Sir / Ken Fulton's article "Read 'Um and Don't Weep" (July 1979 issue) was quite good, but I have an addition to it. As a planetarium director and long-time amateur astronomer, I have been fielding questions about telescopes for years. When someone calls and says, "I want to buy a telescope. Which is the best one?", I give them the following advice which I feel should be added to Mr. Fulton's article as point 9:

9. Find the Local Astronomical Society or Club.

You will find some form of astronomy club in every city or town of any size. Seek it out. If there is a planetarium around, the director will likely know how to find the club. A year's club dues might be the best investment you can make in preparing to purchase a telescope.

Go observing with the club. There will be many telescopes at the star

parties, so look through all of them. Ask the members what they think about various different types of instruments. After some experience with using telescopes, you will be much better prepared to make a decision.

You will find that the club is made up of people like you who are interested in astronomy and can help you as you learn.

John Cotton
Dallas, TX

Mr. Cotton / Hear, hear!

Sir / Through a variety of circumstances, I recently had the opportunity to visit and observe through the 92-inch infrared telescope which the University of Wyoming had built on Jelm mountain just outside of Laramie. I'm sure you can imagine the awe I experienced at being able to touch and observe the heavens through this magnificent instrument. As an amateur astronomer, I shall never forget the experience of looking deep into the heart of the M-13 cluster through 92 inches of aperture. The view was breathtakingly indescribable!

wrapped, labeled and into the mail by the 7th. Your copy probably reached you during the final week of August.

Of course, sometimes things go wrong in such a schedule — our cover shot came out much too dark due to an inking problem on press, and a picture of the Great Spot came out looking more like a Great Smoked Salmon Spot than Red. So we had a BIG MEETING and we complained, and last month they did a fine job on press. I think it's safe to promise improved printing quality in the next several months.

Lots of readers have noticed — and been delighted — that we're putting more complex articles into Stellar Frontiers. This department deals with the frontiers of knowledge in astronomical research, and it's a more difficult, more mind-boggling, and more advanced department than the rest of ASTRONOMY. We're glad to know you appreciate it.

We've done some exploring with our feature articles this summer, too — we've sandwiched such exotic topics as gravity waves, quarks and the origin of the universe, and radio interferometry between the exciting planetary flybys. We've done our darnedest to make these topics, very much part of modern astronomy, come alive for you in readable language you can get your teeth into. All indications are that you — our readers — loved it.

At the same time, ASTRONOMY's growth has brought us many new astronomy enthusiasts, so my mail has been running heavy with good, solid, basic questions about observing, using a telescope, and astrophotography. We're setting out to answer those questions. We're also promoting an editorial philosophy designed to help both new

readers and long-term readers as well — with the best, most reliable, most honest "how-to" articles ever written. Why? Because you've let us know that you want it that way!

Another change, the adoption of our current cover logo and design (beginning with the April cover), provoked some cries of "foul" from readers who've been with us for a long time. We agonized over the decision to make the change — now we're glad we did because the new cover has ultimately proven very popular. But another change is upon us.

Beginning with the January 1980 issue, we'll carry the little Universal Product Code "thing" in the lower left-hand corner of the cover. Almost every magazine now has one of these little marks. Someday when you buy a magazine "off the racks" (ASTRONOMY is now carried on some 900 newsstands across the country), along with a loaf of bread and a can of cat food, the clerk will scan the code numbers and the price will appear automatically on the register.

And finally, we've had very good comments on the new Forum department. One thing is for sure, our mail tells us you're reading it. If you'll just keep those idea-filled postcards and letters coming, we'll keep putting your ideas into action.

Our growth has prompted us in another direction also. This spring we did a comprehensive survey of our readership. You might have been one of the randomly-chosen subscribers who received our questionnaire.

The results really surprised us a bit. Since our 1974 survey was made, our readership has changed appreciably. The average reader (a mythical creation, since we know we're dealing with 100,000 individuals) is older, more educated, and more knowledgeable

than ever before. You have an average age of 35 — several years older than our previous survey — and are distributed almost evenly throughout the entire range of ages from about 15 through the 70s. That really pleases us: Astronomy seems to bring together people of all ages. The "average" reader has had three years of college education, and 31% of you went on to post-graduate studies.

Professional occupations account for 31% of ASTRONOMY readers; some 20% are students, 15% are engineers or scientists not specifically engaged in astronomy, and 9% are educators or librarians.

Most of you are happy with ASTRONOMY; in fact 92% of you felt that ASTRONOMY is as good, better, or much better than you expected. You expressed a strong desire for a magazine that's easy and informative to read, a magazine that gets to the heart of the matter without a lot of dull technical details. (That's what we try to do!) You don't want to be "talked down to," but you want to learn from ASTRONOMY. Four-fifths of you keep your copies of ASTRONOMY indefinitely. We're proud that you think ASTRONOMY is worth keeping.

What you all seemed to want is a bigger ASTRONOMY Magazine. "Keep up the great work, but please include more about..." was a very common comment. Well, we're trying.

Next month, I'll tell you more of what we've learned from the survey — so stay tuned....

Sincerely,

Richard Berry

Richard Berry
Editor

Ideal Gifts!

Inexpensive • Functional • Long lasting
NegaFiles for photographic slides negatives, and prints.

35-G-4-100



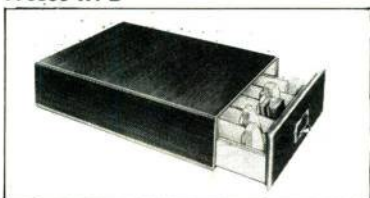
\$32.95 Portable. Files 1200 exposures 35mm strips of 4. Comes with 100 transparent acetate sleeves, index card and numerical (10-100) printed guide cards.

375



\$31.95 Portable. Files approx. 1000 2x2 slides. Visible movable tabs for filing by subjects. Brass plated hardware. Solid mahogany. Lock corner construction.

A-3500-WFB



\$44.95 Files thousands of 2x2 slides. Equipped with rods and follow blocks like regular large correspondence files. Brass plated corners for stacking included.

Clear Acetate Sleeves.



Transparent, long-lasting, open at both ends. White printed strip for writing identification. Ideal negative protection

Negative Capacity

6 35mm

4 35mm

1 35mm

1 4 X5

1 2 1/4 X 3 1/4

3 2 1/4 X 2 1/4

4 2 1/4 X 2 1/4

1 2 1/4 X 2 1/4

Item No.

35-A-6

35-A-4

35-A-1

45-A

20-A

22-3A

22-4A

24A

NegaFile

Call or write for free catalog.
NegaFile Systems, Inc.
Box 78, Dept A-3, Furlong, PA 18925
Call: (215) 348-2356



The point I want to make is that since this telescope was built in large part with public funds, it is made available to the public for display and demonstration once a month. This date is termed "Public Night" and I'm sure further information may be obtained through the Physics Department of the University of Wyoming, Laramie, Wyoming. Your readers in the western part of the United States may appreciate knowing this fact. I'm sure any full-blooded astronomy nut would love the opportunity to visit a true "large" telescope.

Gary K. Lund
Athens, GA

Sir / Last night, June 21, I went outside with my telescope and field glasses to look at the general area of Cygnus in the east. At about 10:50 p.m. EDT, I saw in the south what I think was a satellite re-entry. Being 14 years old, I have to say that this was the most spectacular event I have ever witnessed. As I watched it blaze through Scorpio, Ophiuchus, Serpens, and Aquila, I saw through my field glasses pieces breaking off of the main object and burning out. At the same time, I thought, "It's Skylab! Skylab has finally come down!" Of course it wasn't, but I do want to know just what I saw. I would appreciate very much hearing from anyone else who might have seen it.

Gerry Russo
Cumberland, RI 02864

Sir / First let me commend you on an excellent article on life in space ("Are We the Only Intelligent Life in Our Galaxy?", ASTRONOMY, January 1979), but let me add a chemist's point of view, possibly different. New discoveries are being made in genetics and organic chemistry every week, and they bear directly on the life-in-space controversy.

The first problem is to understand what life is. Life is highly directional; every time a laser beam goes out or a telescope is pointed into space, this fact is verified. Life is a thermodynamic fluctuation gone berserk, a fluctuation that keeps on going in one direction. Genetic replication (in which one molecule acts as a pattern for the making of another) and species evolution are parts of this directional character. Life on Earth does not, in the ultimate analysis, consist of millions of species; the human fetus goes through all the essential elements of evolution, looking much like a reptile and bird in early stages. The human being is simply the current net result of a long string of molecular replications and refinements. Recent research shows that genes can even repair damage in themselves to keep

this process going, and this is a molecular mechanism, not a life-cell mechanism.

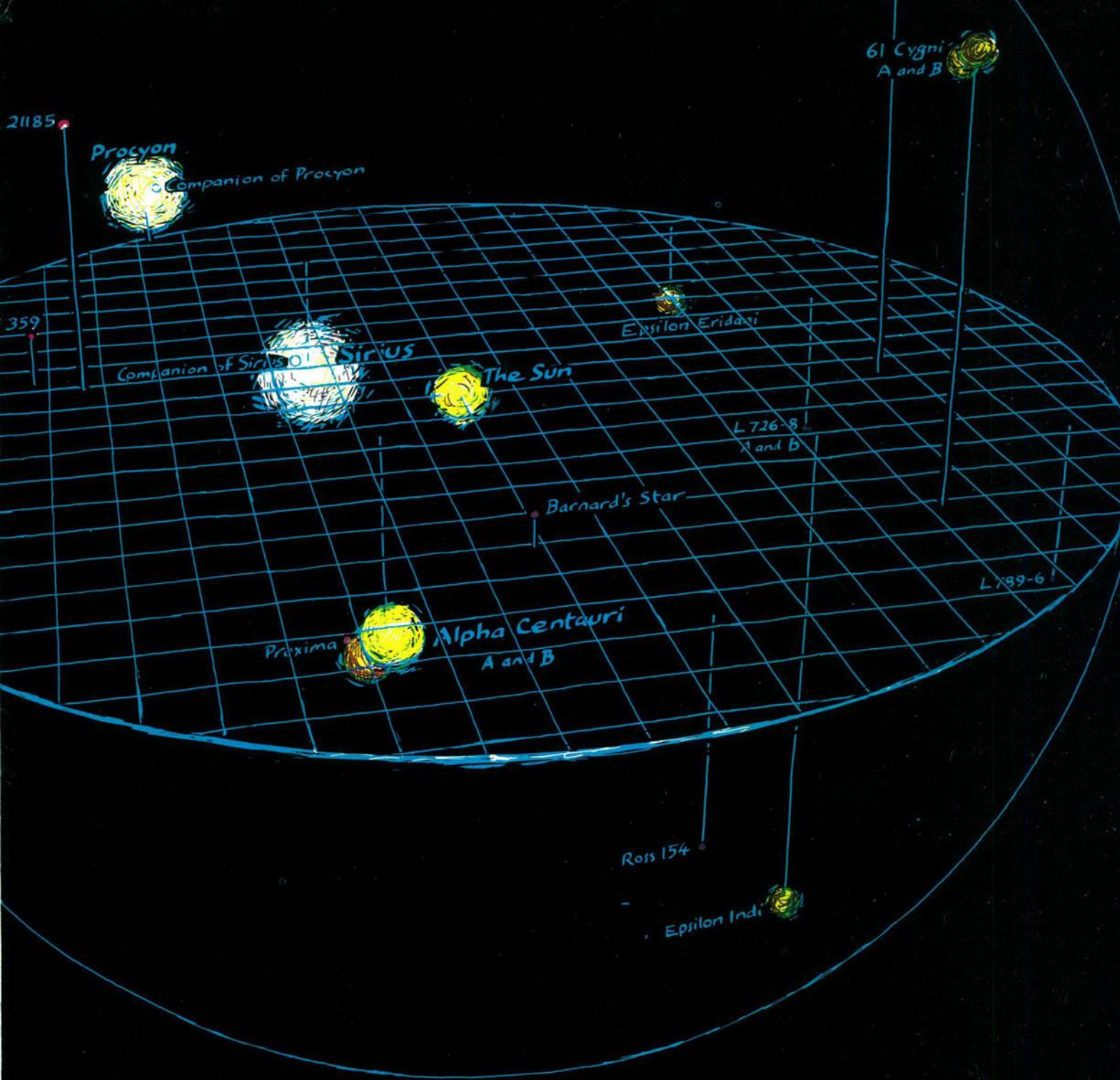
Furthermore, modern research is showing more clearly every day that molecular replication is not a rare process. It is probably a characteristic of certain types of large organic molecules, and organic chemistry is filled with polymeric reactions which build large molecules (as from amino acids). The primary requirement for life is not "accident," but a simple mix of carbon, hydrogen, nitrogen, oxygen, solvent, and temperature — conditions that must exist in billions of places in the universe. A planet with less water than Earth would very likely be more probable for life generation. All kinds of photosynthetic mechanisms are being discovered for the generation of oxygen from carbon dioxide and other oxygen compounds.

In a sentence, the pessimistic view of life in space is based on lack of knowledge. The current trend in chemical understanding is making life elsewhere more probable every week.

But human beings tend to see things in a very narrow, subjective way. We are certainly not the highest form of intelligent behavior. A superior being might have a built-in mechanism for refining itself (like genes already do through selection processes), with little interest in our "high technology" and destructive nuclear devices, wars, etc. In fact, a superior being would very likely regard the human race as insane, with the barest rudiments of life characteristics. The "need to know", beyond a certain health stage, may actually be self-destructive. A super-intelligent being might have no interest in conquering a galaxy, or even communicating with other life. (He might also know that such communication is either impossible or pointless.) Somehow, possibly with the help of computers, Homo sapiens have to learn to see other points of view. There is also the very real possibility that if he doesn't learn, the human race will be all through in about a hundred years. Our high technology we boast so much about will destroy us (when phosphate runs out, if nothing else) if we don't develop a little humility in a big hurry. To sum up, life elsewhere in the universe may well be more directional and self-preserving than we are.

Assuming that we are the only life in the universe is the ultimate ego trip, typically human. That we are accompanied by the most common type of star in the universe is, just by itself, highly significant. Life, like neutron stars and supernovae, is a phenomenon of the universe, not so flashy maybe, but no less remarkable.

Edwin H. Tompkins
Riverside, IL



ASTRONOMICAL COMPANION

THE ASTRONOMICAL COMPANION

\$12 postpaid

A series of more than 30 tremendous 3-dimensional illustrations, ranging from the earth and moon to the whole universe, is just one of the features of the *Astronomical Companion*. Titles of some of the 40 sections are OVERVIEW OF ASTRONOMY, FOUR PLANES, ORIENTING TO THE SKY, STAR NAMES, ZODIAC, SEASONS, CALENDARS, CHRISTMAS, MOONLIGHT, EARTHLIGHT, MOON AS SIGNPOST, ECLIPSE SEASONS, SAROS, COMETS, DISTANCES, NEAREST STARS, BRIGHTEST STARS, H-R DIAGRAM, EVOLUTION, and the OUTRUSH, a final sequence of expanding spheres.

ASTRONOMICAL CALENDAR 1980

\$8 postpaid

The famous annual illustrated description of celestial events, now used by most colleges, planetariums etc. and in nearly 80 countries.

The page size of both the above books is 11 × 15" (nearly twice the size of a page of this magazine).

VIEW FROM THE EARTH 1980

\$4 postpaid

Simplified version of the *Astronomical Calendar*, for children.

Order these books by Guy Ottewell from: **Astronomical Calendar, Furman University, Greenville, S.C. 29613, U.S.A.** Please make checks payable to "Astronomical Calendar".



ASTRONOMY REVIEWS

Project Daedalus

by the Project Daedalus Study Group

192 pages (illus.), softcover, \$12.00
The British Interplanetary Society,
12 Bessborough Gardens, London SW1V 2JJ
United Kingdom (1978)

In 1933, a group of English space enthusiasts founded the British Interplanetary Society (BIS). Six years later the BIS presented the world with the first engineering study of how to build a manned moonship. The study suggested that the technology necessary to make a Moon landing possible should be available by the year 1978, a very daring prediction at the time. Scientists outside the BIS, although generally cordial to the amateur effort, were skeptical of the assumptions behind the rocket's design. Yet thirty years later, the lunar module which landed Neil Armstrong and Edwin Aldrin on the Moon's surface embodied many of the features proposed in that early BIS study.

Recently the BIS completed another engineering study, **Project Daedalus**. This even more ambitious report concerns itself with the building of the first unmanned *starship*. Since its inception in 1973, well over ten thousand hours of work were spent on the study by a group of thirteen scientists and engineers.

The automated probe envisioned by the team is designed to make a fifty-year trip to Barnard's star, six light-years away, and beam information on that star system back to Earth. Barnard's star was chosen as a target because it is believed to have planets whose gravitational pull accounts for the way the star wobbles in its path through space.

The huge two-staged Daedalus probe would be powered by laser-pulse fusion engines, which would accelerate the payload to a final velocity of almost 14% of light-speed or 92 million miles per hour.

For fuel, the probe will need thirty thousand tons of helium-3 and twenty thousand tons of deuterium (heavy water). The authors believe the best source of these materials is the atmosphere of Jupiter.

Since direct command and control from Earth is impossible due to the length of time it takes a message to reach the probe, an onboard artificial intelligence (supercomputer) would oversee the entire mission.

The study goes on to predict that it might be possible to launch a Daedalus-type star probe in the latter part of the 21st century.

The reaction of the scientific community to this report is very similar to the response which greeted the earlier moonship concept. However, the Daedalus study group must be applauded for their immense ingenuity and foresight in the creation of this remarkable document. Of course there'll be carpers and nitpickers, but what counts is that *someone* is attempting serious planning.

The large format of the report (8" x 11") is crammed with line drawings and technical illustrations. All aspects of the mission are covered, from selecting nearby stellar targets, to very detailed feasibility studies of the propulsion system, acquisition of fuel, vehicle construction, navigation, and communications.

For these reasons, this study is probably rather dry and technical for the average reader. But for the budding aeronautical engineer, this is the stuff dreams are made of. The **Project Daedalus** report is likely to become the most quoted of documents on starflight for the next few decades.

Limited quantities of this report are available from the British Interplanetary Society at the above address.
Thomas R. Schroeder.

Spaceships of the Mind

by Nigel Calder

144 pages (illus.), hardcover, \$14.95
The Viking Press (1978)

For the past decade, western society had been immersed in a prevailing mood of despair and futility concerning our future. Among some people, however, this feeling of pessimism appears to be on its way out and this

book could become one of the major reasons for its departure.

In 1978 the British Broadcasting Corporation produced a television series relating to possible ways of engineering a better future. This book is the print version of that series. Readers familiar with Nigel Calder's other works, **The Key to the Universe**, **The Restless Earth**, and **The Weather Machine**, will recall that they also began as BBC documentaries.

The principal strength in any of Calder's books is that they are easy to read. The writing, generally, is fast paced, very informative, and most entertaining. The author's present work is no exception.

In a world of limited resources we are beginning to feel the first hunger pangs — not enough energy, not enough raw materials, and not enough room to live. But Calder spreads tantalizing visions before us like a banquet before a starving man: the limitless power of the Sun; the immense natural resources to be harvested on the Moon and asteroids; and the possibility of living on countless manmade worlds in space. Much of this makes a convincing argument for a healthy space program.

As Mr. Calder sees it, the first prerequisite for this needed leap upward is the "Big Idea." He defines a Big Idea as any concept which "captures the enthusiasm of people who will struggle against great difficulties to make it happen." Many of these Big Ideas or "Spaceships of the Mind" will be familiar to the readers of **ASTRONOMY** magazine: Gerard O'Neill's space colonies (Jan. '76), Brian O'Leary's asteroid mining ideas (Nov. '78), and the Daedalus Starprobe (March '75 & Aug. '77).

Other notions, perhaps less well known include Theodore Taylor's Santa Claus machine (a huge self-renewing factory which eats asteroids and turns them into any desired product), and Freeman Dyson's artificial biosphere around a star. These and many other concepts provide an exhilarating arena for conjecture, and not all these ideas are confined to the vacuum of space.

Among Calder's earthbound Big Ideas we find: John Todd's New Alchemy Institute, Edward Wilson's sociobiology, and even E.F. Schumacher's "small is beautiful" movement. These scientific, economic, and social concepts have been gathered from laboratories and research centers all over the world. Not only are these grand schemes lucidly explained, but we also catch a glimpse of the people who gave birth to them.

This slim volume abounds with hope for the future. The really exciting thing is that a few of these ideas might serve as the blueprints for generations to come.

Black and white as well as some color photographs help to punctuate the text. Other useful visual aids consist of illustrations and models of some spaceships made for the BBC documentary.

My only complaint about the book is that I was done with it all too quickly. Nigel Calder has provided us with several appetizing futures and these make **Spaceships of the Mind** a pure joy to consume. *Thomas R. Schroeder.*

The Crab Nebula

by Simon Mitton

184 pages (plus glossary
bibliography and index)
hardcover, \$14.95
Charles Scribner's Sons (1978)

As the author states, the Crab Nebula is one of the finest physics labs in the sky, and thus has a definite importance in the development of modern astronomy and astrophysics. The discovery and interpretation of its central pulsar power source ranks as a major scientific advance of this century. Making the connection between the nebula and historical records provided one of the foundation stones for expanding archaeoastronomical inquiry. Mitton has performed a service by collecting the history and understanding of the Crab in this condensed and readable form.

The book's eleven chapters are grouped into three major sections: historical, physical, and a perspective on modern astronomy. The historical chapters are fascinating in that Chinese, American Indian, and Arabic records are presented in detail, and followed by the detective story of astronomers puzzling over the nebula earlier this century. (The historical records are not yet fully studied, despite the "case-is-closed" implication in the book.) Mitton also provides a bridge between amateur and professional astronomers by discussing

where in Taurus the Crab may be seen, complete with finder charts.

After the historical aspects, more details of observations are introduced, blended with increasing physical explanation. Here the book begins to read unevenly: some passages lucid, others launching into detail usually reserved for introductory graduate texts. Nonetheless, Mitton's ability shines through in his chronicle of the crucial observations (like the discovery of the optical pulsar). For some reason, however, he inserts unnecessarily dogmatic statements like "mass density is the right way to look at these things" (p. 62) when referring to critical measurements of the high energy spectrum of the Crab. And cynical discussion of the "finding game" (p. 84) would probably earn Mitton a punch in the nose from the authors of the proposals he paddles! Further, his criticism might have been more palatable if he'd participated in the scientific research under discussion as opposed to his simply playing historian. The destructive criticisms are inappropriate here.

After considerable discussion of observations and physics, Mitton gives a concise summary of the fundamental data of the pulsar — those which set the severest constraints upon theorists. Since these data (concerned with the strength, polarization and slow-down of the pulsed radiation) upheld the rotating neutron star/magnetosphere theory of Gold and Pacini, it is useful to restate the problem succinctly as Mitton does before completing the discussion of theories.

In his final chapters, Mitton attempts to place all of this into perspective: the Crab Nebula as one of many supernovae remnants, and the importance of the Crab to all astronomical studies. He makes the very valid point that amateur astronomers with modest equipment (25 cm aperture) in good sites could be making systematic patrols of the 200 or so galaxies brighter than 12th magnitude. These galaxies might be expected to have supernovae at least this bright, and statistically you could expect several per year overall. Along with amateur monitoring of variable stars, comet and minor planet searches, this patrol would add valuable scientific data.

To conclude, this handsome, short book provides a useful summary of the recent state of our collective understanding of the energetic Crab Nebula. Students, particularly graduate students in this field, will find this book a valuable condensation of relevant observations and theory. The glossary, bibliography and index,

though short, add to the work. *Robert Stencel.*

NEW BOOKS

Foundations of Astronomy

by Richard Knox

184 pages, hardcover, \$10.95
John Wiley & Sons (1979)

Richard Knox is a Fellow of the Royal Astronomical Society (of the U.K.), and has written two other books on astronomy, primarily from an observational viewpoint. Here, he is presenting a popular level book on the growth and present knowledge of astronomy.

Viking Lander Imaging Investigation: picture catalog of primary mission experiment data record

by Robert B. Tucker

560 pages, paperback, no price given
NASA (1978) [order as NASA Reference
Publication 1007 from NTIS,
Springfield, VA 22161]

This book publishes in black and white all the photos returned by the two Viking landers during the "primary mission," which lasted from touchdown until November 7, 1976. Supplementing the photo-record are pages of tables giving the background data on each frame — Sun altitude and azimuth, time and date of exposure, filter used, etc. The photos are not reproduced at best possible size or quality; this is a catalog.

Look to the Night Sky

by Seymour Simon

88 pages, paperback, \$2.95
Puffin Books (1979)

Aimed at children 8 years and older, this is an introduction to the stars and constellations. In addition to explaining how to find them, the author retells the various legends associated with the constellations. There are also short sections on the Moon, planets, comets, and meteors.

Double Stars

by Wulff D. Heintz

174 pages, hardcover, \$29.00;
paperback, \$14.00
D. Reidel (1979)

This is a revised translation of the author's *Doppelsterne* which was published in 1971. The intended audience is at the graduate student level or higher. Basically, the book is a thorough-going survey of the subject which emphasizes properties (and how to determine them) rather than individual stellar systems.

EARTH IN SPACE GLOBE



Farquhar Transparent Globes, Inc.
Dept. A
5007 Warrington Ave.
Philadelphia, PA 19143

Please send me Earth-in-Space Globe Model # _____. Add shipping and handling charges of \$7.50 for 14" thru 20" units. \$40.00 for 36" units. I enclosed check or money order for _____. Pennsylvania residents add 6% sales tax.

Please charge my Master Charge ☐ BankAmericard ☐

Card # _____

Expiration Date _____

ESH 14" \$149.00 • ESH 16" \$185.00 • ESH 20" \$240.00
ESH 36" \$550.00 • ESH 36" with 5' high floor stand \$595.00

Name _____

Address _____

City _____ State _____ Zip _____

Signature _____

FARQUHAR®

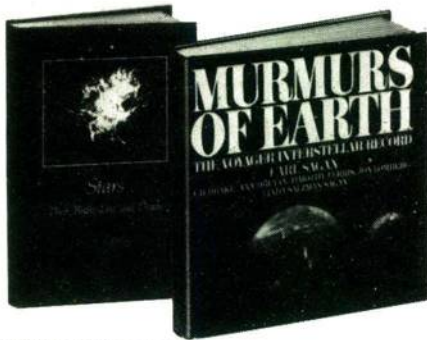
MAKES THE UNIVERSE CLEAR

The Farquhar transparent, three color star globe is the most beautiful and dramatic method of bringing the universe inside of your world. It puts the stars at your command. You can adjust the star globe with over 1100 stars to correspond to any location and time on Earth. This great ball of knowledge offers a universe of features; all 88 constellations, names and distances in light years of brighter stars, milky way, ecliptic path of the sun, precessional path of the north and south celestial poles and much more, including our instruction manual. The universe comes in your choice of four sizes. Put one in your world today.

The origins of the solar system... stellar evolution... colonies in space... black holes... the red planet...

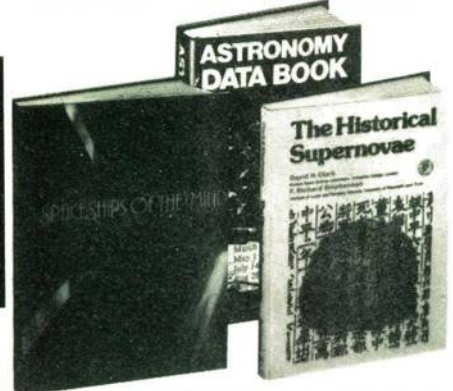
Sooner or later, all of the secrets of the heavens are revealed in the *only* book club of its kind, the

Astronomy Book Club



**Take any 3 books
(values to \$58.95)
for only \$1.00 each**

If you will join now for a trial period and agree to take 3 more books—at handsome discounts—over the next 12 months



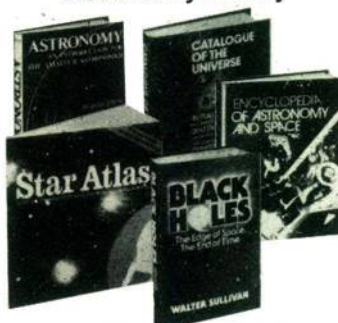
(Publisher's Prices shown)

- 84288. TIDES AND THE PULL OF THE MOON.** Francis E. Wyllie. Lunar and tidal phenomena and their influence on our life. Illustrated. **\$12.95**
- 55001. ILLUSTRATED ENCYCLOPEDIA OF ASTRONOMY AND SPACE.** 2nd Ed. **\$17.95**
- 36400. BLACK HOLES** Walter Sullivan. A fascinating journey of speculation and discovery. **\$17.95**
- 37353. CATALOGUE OF THE UNIVERSE.** Three volumes-in-one: an atlas, encyclopedia, and book of descriptive astronomy. **\$15.95**
- 34661. ASTRONOMY: An Introduction for the Amateur Astronomer.** Jacqueline Mitton. **\$7.95**
- 79725. SPACE TREK: The Endless Migration.** Glenn and Robinson. Presents the economic, political, and philosophical effects of space colonization. **\$9.95**
- 80250. STARS: Their Birth, Life, and Death.** Josif S. Shklovskii. **\$17.50**
- 63217. MURMURS OF THE EARTH.** Carl Sagan et al. The story of the recorded messages carried by the Voyager space probe. **\$15.00**

- 53585. A HOUSE IN SPACE.** Henry S. F. Cooper, Jr. Skylab's unique experiments and observations as well as a behind-the-scenes look at the astronaut's experiences. **\$8.95**
- 80585. STELLAR EVOLUTION.** A. J. Meadows. The modern theories of the origin and evolution of stars explained in understandable language. **\$16.50**
- 53015. THE HISTORICAL SUPERNOVAE.** Clark and Stephenson. Detailed study of supernova remnants. **\$16.50**
- 85461. UNTIL THE SUN DIES.** Dr. Robert Jastrow. Account of the creation of the universe and the evolution of life. **\$8.95**
- 69303. PLANETARY ENCOUNTERS.** Robert M. Powers. The case for all-out exploration of our solar system in this century. **\$13.95**
- 84353. TO THE RED PLANET.** Eric Burgess. Accounting of Viking mission. **\$19.95**
- 66560. OUTER SPACE PHOTOGRAPHY FOR THE AMATEUR.** Henry E. Paul. **\$10.95**
- 69327. PLANETS AND MOONS.** William J. Kaufmann III. The unfolding picture of our planetary neighbors revealed by modern astronomy. **\$13.00**

- 79735. SPACESHIPS OF THE MIND.** Nigel Calder. Scientifically plausible proposals for man's self-directed evolution and his colonization of space. **\$14.95**
- 57833. THE LAROUSSE GUIDE TO ASTRONOMY.** David Baker. Packed with color photos and illustrations. **\$15.95**
- 80255. STARS AND NEBULAS.** William J. Kaufmann III. Covers everything from radio signals in space to time as the fourth dimension. **\$13.00**
- 58585. LIFE ON MARS.** David L. Chandler. Speculates that life may indeed be present. **\$9.95**
- 34678. ASTRONOMY DATA BOOK.** Robinson and Muirden. Single-source guide to technical information. **\$12.95**
- 82735. TELESCOPES FOR SKYGazing.** Henry E. Paul. Classic reference to buying, building, or using telescopes. **\$10.95**
- 66275-2. THE ORIGIN OF THE SOLAR SYSTEM.** S. F. Dermott. Counts as 2 of your 3 books. **\$39.00**

Basic Astronomy Library



Here's a carefully selected set of five books that will provide you with a basic, well-rounded astronomy library. First, a "must" for any astronomy reader, the **Illustrated Encyclopedia of Astronomy and Space**. Then, Jacqueline Mitton's invaluable introduction to the fundamentals, **Astronomy: An Introduction for the Amateur Astronomer**. Next, a marvelously readable overview of the latest advances in the "new astronomy," Walter Sullivan's **Black Holes**. Then, the **Catalog of the Universe**, which features more than 300 photographs. Finally, a useful guide that will show you how to locate and identify more than 4,000 stars that are visible to the naked eye, **Star Atlas**. **Publishers' price for five-book set: \$61.75.** Counts as 3 of your 3 books. To order check **Basic Astronomy Library-A** on your coupon.

4 Good Reasons to Join

- 1. The Finest Books.** Of the hundreds and hundreds of books submitted to us each year, only the very finest are selected and offered. Moreover, our books are always of equal quality to publishers' editions, *never* economy editions.
- 2. Big Savings.** In addition to getting either the **BASIC ASTRONOMY LIBRARY** for \$3.00 or any other 3 books for only \$1.00 each when you join, you keep saving substantially—up to 30% and occasionally even more. (For example, your total savings as a trial member—including this introductory offer—can easily be over 50%!)
- 3. Bonus Books.** Also, you will immediately become eligible to participate in our Bonus Book Plan, with savings of at least 70% off the publishers' prices on any book offered in the Club.
- 4. Convenient Service.** At 3-4 week intervals (16 times per year) you will receive the Book Club News, describing the Main Selection and Alternate Selections, together with a dated reply card. In addition, up to 3 times a year, you may receive offers of special selections, always at substantial discounts. If you want the Main Selection, or the special selection, do nothing and it will be sent to you automatically. If you prefer another selection, or no book at all, simply indicate your choice on the card, and return it by the date specified. You will have at least 10 days to decide. If, because of late mail delivery of the News you should receive a book you do not want, we guarantee return postage.

Astronomy Book Club Riverside, New Jersey 08370

L-A6A

Please accept my application for trial membership and send me either the three volumes indicated, billing me \$1.00 each, or the **BASIC ASTRONOMY LIBRARY**, billing me only \$3.00. I agree to purchase at least three additional Selections or Alternates during the first 12 months I am a member, under the membership plan described in this ad. Savings range up to 30% and occasionally even more. My membership is cancelable any time after I buy these three books. A shipping and handling charge is added to all shipments.

- ☐ Check here if you want the **Basic Astronomy Library-A (35558)**.
- ☐ Check here if you prefer three other volumes for \$1.00 each, and indicate below the numbers of the books you want.

--	--	--

A few expensive books (noted in book descriptions) count as more than one choice.

No-Risk Guarantee: If you are not satisfied—for any reason—you may return your 3 books—within 10 days and your membership will be canceled and you will owe nothing.

Name _____

Address _____

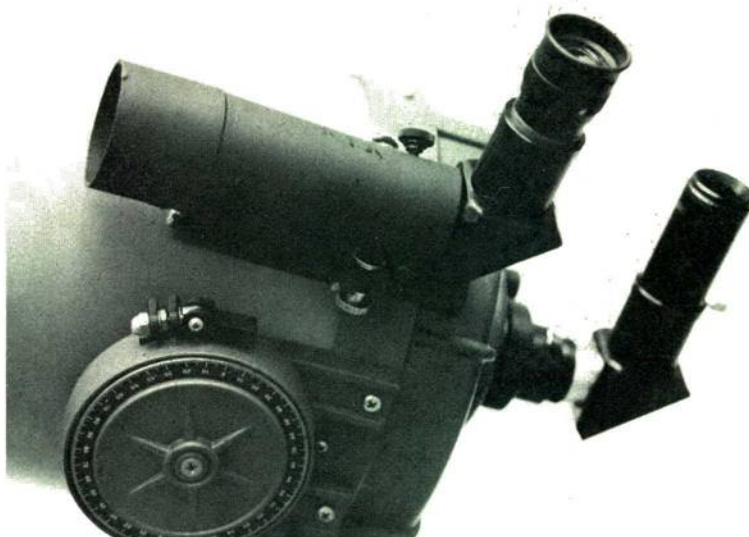
City _____

State _____ Zip _____

(Offer good in Continental U.S. and Canada only. Prices slightly higher in Canada.)

ALL CELESTRONS ARE NOT THE SAME —

**WHEN YOU INVEST IN OUR
SUPER CELESTRON 8**
the following
**CUSTOM ENGINEERED
ACCESSORIES ARE FREE!**



LARGE 50mm SUPER FINDER

This new finder mounts in place of the standard 30mm unit. It can be used right angle or straight thru. Comes 7 or 8 power, your choice, and takes standard eyepieces. Gathers three times the light and has twice the field of view. See some Messier objects clearly.
(Value \$79.)

POLARIS POINTER & PRECISION POLAR AXIS FINDER

These two devices permit you to accurately line up on the Celestial pole in minutes without tools, without knowing your latitude, without shimming or leveling your tripod. Makes finding things with your setting circles a snap.
(Total Value \$128.)

MICRO DRIVE

A special gear reduction unit mounted so as to make the manual adjustment of the correct R.A. setting ten times easier. Increases accuracy of setting R.A.
(Value \$59.)

SOLAR SKREEN® & CELL

A full aperture SAFE high resolution sun filter. Mounts without glue or magnets. SEE Sky and Tel April 1979 pg. 366.
(Value \$59.)

You get all these things and other gifts and services worth over \$80 plus our unique lifetime guarantee on the Celestron motors.

Get the full story on our New Giant Rich-Field Super Finder — a valuable aid to locating objects, the hardest part of our great hobby. Send a LARGE (7"x9") Self-Addressed Stamped Envelope (S.A.S.E.) for any of the following FREE ITEMS:

- Our NEW 26-page Astronomical Catalog
- Tuthill's Twenty Two Telescope Tips
- Our Comet Award Program
- User report on STEREOGOCULAR

- Tuthill's Maintenance Instructions for Celestrons
- Z-1000 Eyepiece Report
- Why Celestron — 18 Reasons

Florida demonstrations now available.

**Financing Available
Master Charge, Visa**

Free Catalog. We take Master Charge and VISA.

**FREE Solar Skreen with every Quantum
scope we sell.**

MONEY-BACK GUARANTEE ON ALL PRODUCTS WE SELL.

*Trade Mark

Telephone: 201-232-1786

ROGER W. TUTHILL, INC. Box 1086A, 11 Tanglewood Lane, Mountainside, N.J. 07092

STRAIGHT TALK about Eyepieces

One look thru a Clavé Plössl Eyepiece will show you what you have been missing. Wide field - sharp to the edge - multicoated - no ghost images - easy to clean - ten focal lengths - all parfocal. Your scope performance may be stunted by not using the best eyepieces. Just try one and you will be convinced. No risk with our money back guarantee. If you don't investigate the best, how can you expect to have the best?

NEW THE ULTIMATE FINDER



- 80mm coated objective F/4
- Takes standard 1¼" eyepieces
- Right Angle or Straight thru
- 11 or 15 power focusable eyepieces with metal crosshairs.
- Brilliant images sharp to the edge.
- Fits any scope without drilling any holes.
- At last a BIG finder for a BIG scope. From ..\$149. Write for Information.

PRECISION POLAR AXIS FINDER*

Get perfect celestial pole alignment quickly and easily every time. When the centered 4x cross hairs are set directly on Polaris, the 0.8-degree offset barrel points precisely on the pole. Novel Polaris date and time chart supplied FREE.

Celestron model 5 or 8 \$79
German Equatorial model \$77
Patent Applied For



**IDEAL
HOLIDAY GIFTS
TO MAKE YOUR HOBBY
MORE ENJOYABLE.**

**CELESTIAL
NAVIGATOR^{T.M.} - NOW THERE ARE TWO**

MARK I Reads the accurate R.A. & Dec. pointing direction of your scope in large easy to read red digits. Includes console, encoders and operates from a 12 v. DC supply. **From \$437.**

MARK II A computer controlled system which drives the scope in seconds to any of the over 200 stored R.A. & Dec. locations and displays the positions as Mark I. You can program your own 25 favorite objects. **From \$989.**

Now you can convert your scope to true observatory-type operation. The accuracy in either unit is one minute in R.A. & 1/6 deg. in Dec. Spend your valuable time observing objects rather than just searching for them. Either unit adapts to Celestron, Observatory or home-built type scopes. Write for full information.

Telephone: 201-232-1786

ROGER W. TUTHILL, INC. Box 1086A, 11 Tanglewood Lane, Mountainside, N.J. 07092

AstroNews

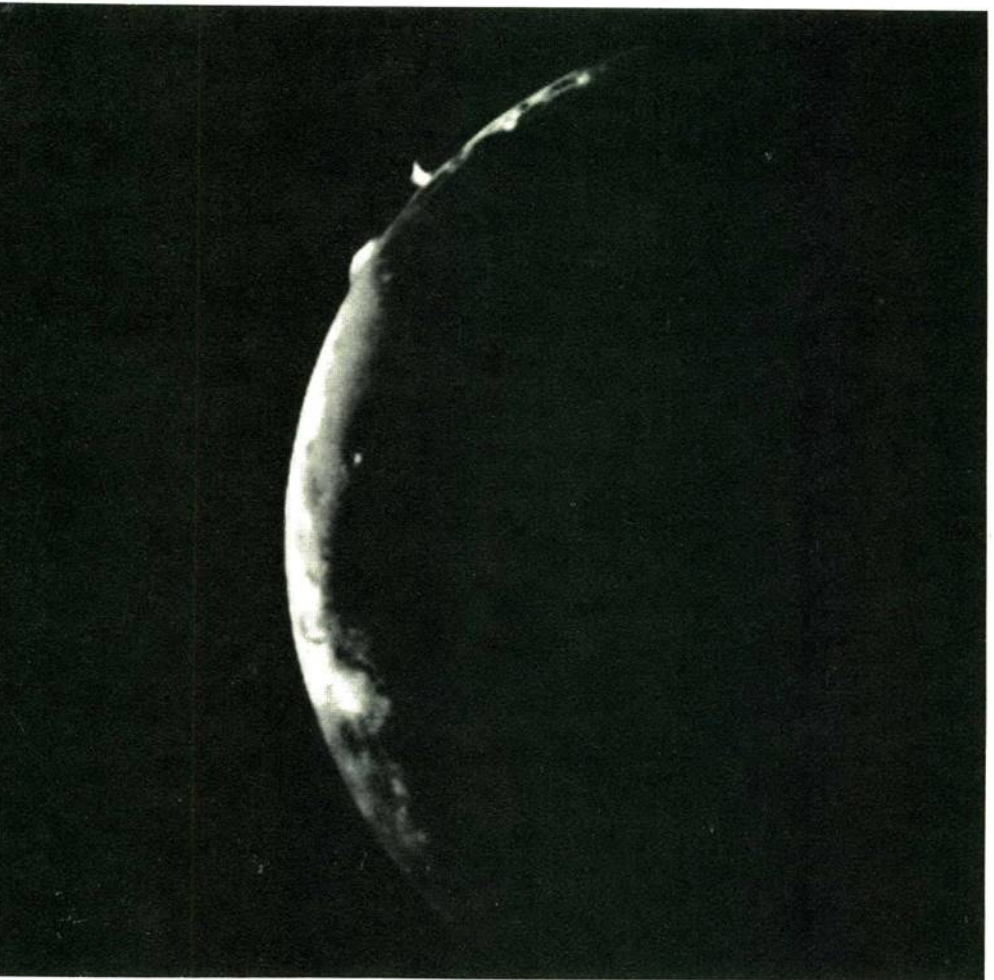
Still More Results from Voyager 1

A second batch of scientific papers analyzing the findings of the Voyager 1 mission to the Jovian system has been published, this time in the English journal *Nature* (August 30, 1979). Fully fifteen of the 27 papers deal with the unique Galilean satellite Io, which is rapidly becoming one of the solar system's most fascinating objects.

Several of the papers on Io deal with the presence of sulfur dioxide (SO_2) both as a tenuous atmosphere and as a surface deposit. Sulfur dioxide has been definitely identified as the primary constituent of a very thin atmosphere, and this gas is apparently in balance with the presence of solid sulfur dioxide on the surface. The source of the gas is probably the numerous volcanos on Io, which would continually replace sulfur dioxide lost to outer space. This escaped gas, broken down by radiation, might account for the observed presence of both sulfur and oxygen in the Io torus, while condensation and precipitation of the gas as a form of "snow" could explain in part the obliteration of impact craters on the surface of Io. Furthermore, Io is apparently notably lacking in hydrogen, carbon, and nitrogen, and this fits in nicely with the observed absence of these elements from the Io torus.

Calculations based on Voyager 1's observations show that Io's SO_2 atmosphere would rapidly escape if it were not continually replenished by volcanic activity, but the observed activity is sufficient to maintain a stable atmosphere of the observed density.

Prominent features in the spectrum of Io indicate an "almost ubiquitous" presence of sulfur dioxide in some form on Io's surface. These features suggest that frozen SO_2 molecules exist on the surface as free frost, as well as in a chemical combination with surface particles. The long-known phenomenon of a sudden post-eclipse brightening of Io may in fact be due



This photograph of Io, taken by Voyager 2 on July 9, shows two volcanic plumes spewing material to a height of about 60 miles. JPL/NASA photograph P-21767.

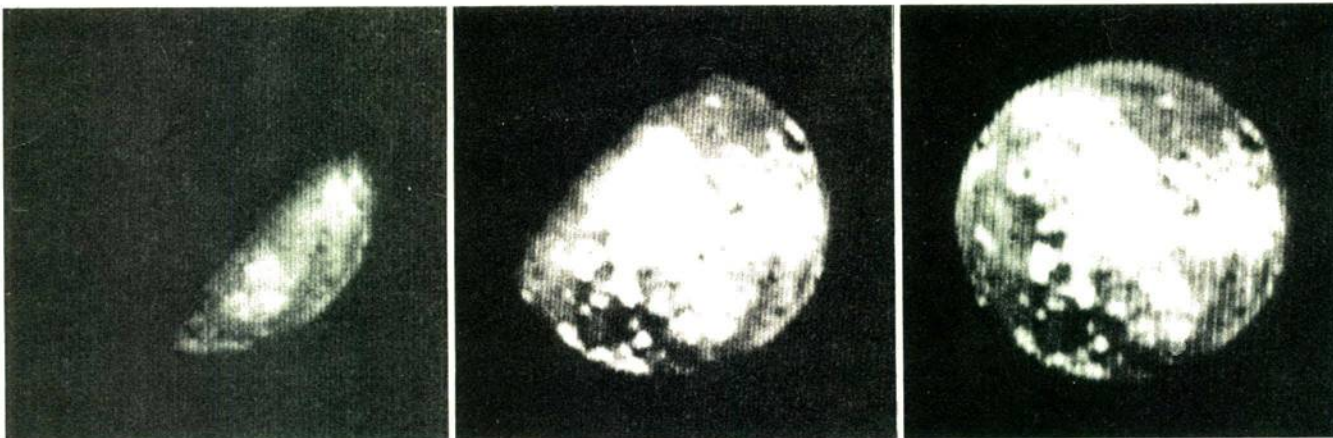
to surface frost, as was first suggested in 1964.

Other papers deal with a preliminary geological mapping of Io, identification of various surface features such as erosional scarps and molten sulfur flows, and the dynamics of the numerous volcanic eruptions.

Several of the remaining papers deal with the dynamics of the Jovian cloud structures. As one notes, "The most striking characteristic of the planet as a whole is the asymmetry in cloud structures between the northern and southern hemispheres." Similar structures observed in the southern hemisphere

Index

- Still More Results from Voyager 1
- Giant Galactic Clouds
- Growing Local Group
- Third HEAO
- Asteroid Satellites
- Isaac Newton Telescope Moved
- Rotating Black Holes?
- Largest Infrared Telescope
- Galactic Secrets Sought



suggest that the atmospheric dynamics which give rise to the Great Red Spot, the smaller white spots, and even smaller spots are the same, but one unanswered question is why the Red Spot should be red while the other features are white.

An analysis of the lightning flashes observed on the night side of Jupiter has revealed a definite connection with certain cloud structures and with an upwelling from below. Thus, such lightning may well be a direct indicator

of the presence of convective currents in the atmosphere.

A final paper on photometric measurements of Ganymede presents results showing that Ganymede's surface is more porous than that of Callisto.

All of the papers are based on observations from the Voyager 1 flyby alone, and it is often noted that the longer time scale afforded by the incorporation of Voyager 2 observations made four months later could lead to significant additional findings.

The three photographs above, taken by Voyager 2 on July 7, show Jupiter's volcanically active satellite Io emerging from eclipse in Jupiter's shadow. The images were taken at one minute, forty second intervals. Io has been observed from Earth to brighten significantly upon emerging from an eclipse, and it has been suggested that this post-eclipse phenomenon is due to the sudden evaporation of surface frost caused by the return of surface-warming sunlight. Voyager 1 observations indicate the presence of a thin sulfur dioxide atmosphere on Io, and prominent features in the reflectance spectrum of Io suggest that this compound is present in a solid form all over Io's surface. Analysis of Voyager 2 data is expected to pin down the exact mechanism.

Giant Galactic Clouds

Astronomers have reported finding the most massive objects yet discovered in the Milky Way Galaxy — about 5,000 gas clouds, each about 200 light-years in diameter and each massing approximately as much as 500,000 suns.

Although a few of these clouds were known to exist, this is the first evidence that they are such an important part of the Milky Way, the galaxy in which our solar system is located.

The only other objects in the Milky Way that approach the clouds in mass are some 200 globular clusters each about the mass of 100,000 suns. Globular clusters are symmetrical groupings — or clusters — of hundreds of thousands of stars which form a sort of halo around the galaxy. The giant molecular clouds are composed of interstellar gas and small solid particles — dust — and lie in the plane of the galaxy.

The astronomers have calculated that the clouds, previously thought to be about 10 million years old, must be at least ten times that — about 100 million years of

age. "This longevity may help to resolve the puzzle of the presence of a complex and advanced chemistry in the clouds, providing adequate time for organic molecules to build up while protected from the ultraviolet light of interstellar space," the scientists reported. The clouds, which radiate no detectable light, are the materials from which new stars are constantly being formed in the galaxy.

The new finding was reported by Dr. Philip Solomon and David B. Sanders of the State University of New York at Stony Brook and Dr. Nicholas Z. Scoville of the University of Massachusetts, at an International Astronomical Union Symposium on Interstellar Molecules held at Mont Tremblant, Quebec.

The three researchers gathered their data during the past three years using a 36-foot-diameter radio telescope operated by the National Radio Astronomy Observatory near Tucson, Arizona, and a new 45-foot antenna at the University of Massachusetts operated by the Five College

Radio Astronomy Observatory (FCRAO). Stony Brook supplies some of the electronics to FCRAO and uses the antenna as part of a contractual arrangement with the University of Massachusetts. The telescopes are the two largest antennae in the United States designed specifically to work with millimeter-length radio waves.

The observations, reported by Dr. Solomon in an invited lecture, show that the largest concentration of the giant clouds of molecules occurs in a broad ring located between 12,000 and 24,000 light-years from the center of the galaxy. The Sun, for comparison purposes, is about 30,000

light-years from the center of the galaxy which is about 100,000 light-years in diameter. The astronomers were able to map the interstellar clouds by detecting the electromagnetic radiation from carbon monoxide molecules in the cold gases.

Drs. Solomon and Scoville first detected the presence of enormous amounts of cold molecular gas in the galaxy in 1974. The new observations, made possible by recent advances in technology and the high resolution of the two telescopes, show that most of the carbon monoxide molecules are contained in the giant clouds which are held together by gravity.

Growing Local Group

The Local Group is the small cluster of galaxies to which our own Milky Way Galaxy belongs and of which M-31, the great galaxy in Andromeda, and M-33 in Triangulum are the other two most prominent members. But in recent years a number of tiny dwarf members of the Local Group have been discovered, raising the total membership to about 30 — still a very small galactic gathering.

Most recently Charles

Kowal of the Hale Observatories has discovered still another probable new member of the Local Group. Found on plates obtained with the 122-centimeter Schmidt telescope at Mt. Palomar on July 25 and 26, the object has a blue photographic magnitude of about 17. Its diameter is about 90 arc-seconds, and individual member stars were resolved. The galaxy is just a few degrees from NGC-6822, at coordinates (1950) R.A. 19^h 27^m 03^s, Dec. -17° 47'. 

Third HEAO

NASA's third and final High Energy Astronomy Observatory (HEAO-C) at this writing is scheduled for launch in September 1979. If successful, the 6500 pound (2948 kilogram) spacecraft will be placed in a low Earth orbit from which it will provide scientists with a capability to study X-rays, gamma rays, and cosmic rays emitted by stars and other objects throughout the universe. The first HEAO was launched in 1977 and the second, now known as the Einstein Observatory, in late 1978.

HEAO-C contains three instruments for studying high energy radiation from space. One of these is a gamma ray spectrometer conceived by Dr. Allen Jacobson of NASA's Jet Propulsion Lab. Gamma rays are electromagnetic radiation just like X-rays, but are even more energetic. A second experiment, conceived by Dr. Lydie Koch of the Center for Nuclear Studies in France and Dr. Bernard Peters of the Danish Space Research Institute, will study the chemical elements which bombard their instrument as cosmic rays after traveling across vast distances in space

from presently unknown sources.

The third instrument is the responsibility of three scientists: Dr. Martin Israel of Washington University, Dr. Cecil Waddington of the University of Minnesota, and Dr. Edward Stone of the California Institute of Technology. Like the French/Danish instrument, it will study cosmic rays, but it is unique in its ability to search for not only the known elements, but theoretically predicted elements heavier than any yet discovered either on Earth or in space.

These trans-uranian elements are predicted to reside in a stable area of the Periodic Table at masses higher than any yet achieved on Earth. The other, less massive elements heavier than uranium have unstable configurations and are all radioactive. If found, the super-heavy elements will be an indication of extremely high energy processes capable of leaping the large gap between uranium and the first of the predicted stable elements — perhaps processes taking place early during the Big Bang itself. ☛

Asteroid Satellites

On February 6, 1973, scientists watching the occultation of a star by the asteroid 2 Pallas recorded observations that indicated the possible presence of a satellite orbiting the asteroid. Since then at least eight other asteroids have, during occultations, exhibited signs of satellites. The most spectacular was the occultation of star SAO 120774 by the asteroid 532 Herculina. Two separate observers saw the star's light dimmed a second time. The indications are that Herculina's satellite is about 50 kilometers in diameter and orbits the asteroid at a distance of about 1000 kilometers.

Now Harold J. Reitsema of the Lunar and Planetary Laboratory at the University of Arizona, in an article in *Science* (July 13, 1979), has issued a word of caution. Reitsema says many of the observations of possible asteroid satellites should be taken with a grain of salt. "There are, in fact, a number of circumstances which can produce spurious occultation observations," he reports. Reitsema says astronomers should place their faith in multiple photoelectric readings — and the stress is on both "multiple" and "photoelectric." ☛

Visual observations of possible asteroid satellites are the most unreliable according to Reitsema, since there's no permanent record of the dimming of the occulted star's light. Such things as airplanes, drifting clouds and atmospheric turbulence can fool the naked eye — and even instruments.

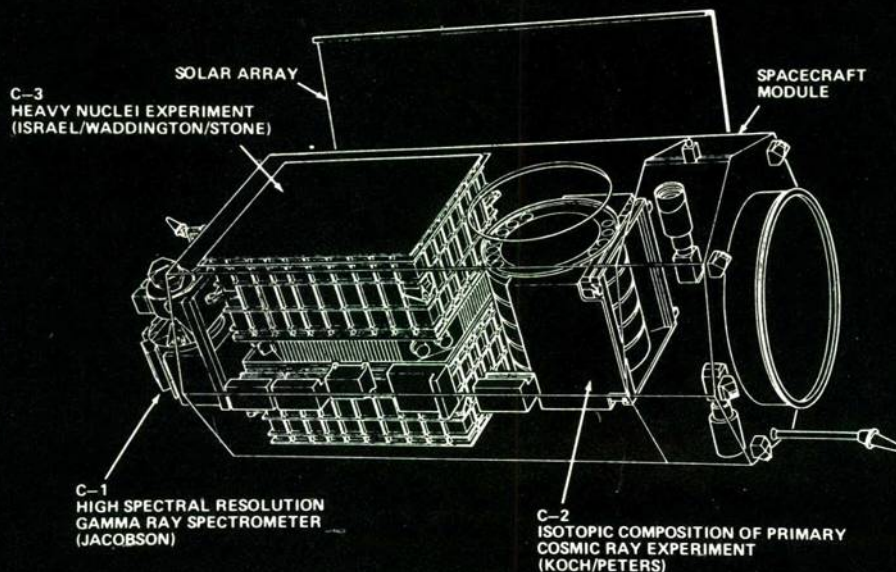
Photoelectric observations are much better because a permanent record, on paper or magnetic tape, is made of the dimming of the starlight by the occulting asteroid and possible companion(s). But since those airplanes and clouds can cause spurious readings, Reitsema warns astronomers to get back-up, confirming readings from at least two observers.

Reitsema points to the Pallas occultation of the star SAO 120836 as a good case in point. The occultation, he reports, was seen from at least four different locations: Calgary, Alberta (Canada); Boulder, Colorado; Denver, Colorado; and the High Altitude Observatory (HAO), Climax, Colorado. The observations at Boulder and from the HAO indicated that Pallas is 800 kilometers in diameter — but it's known to be no more than 560 kilometers. Observers at Denver saw the asteroid — but no occultation at all. The Boulder recording indicated an asteroid satellite, but their readings are totally inconsistent with those from Calgary. And a later close look at photos taken at Las Cruces, New Mexico shows that the path of the occultation was actually so far north of the U.S.-Canadian border that the astronomers at Boulder and with the HAO couldn't even have seen the occultation.

So are there any asteroid satellites? Reitsema is not saying there aren't, but he is saying the evidence isn't really that conclusive — perhaps not even for the Herculina event.

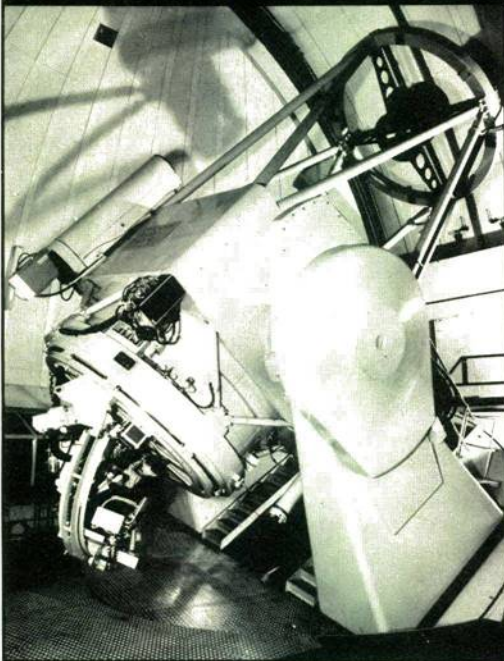
"Many more reliable observations are needed before the frequency of such multiplicity can be discussed," he concludes. ☛

HEAO-3 EXPERIMENTS



The three main experiments aboard HEAO-3 are diagrammed at left, along with the names of the principal scientist-investigators assigned to each. NASA diagram.

Isaac Newton Telescope Moved



The 100-inch Isaac Newton telescope, seen above at left, has been dismantled and moved from its original site at the Royal Greenwich Observatory in Sussex, England to the new international Roque de los Muchachos Observatory on the 8000 foot summit of La Palma in the Canary Islands. (See "Isaac Newton on La Palma" in last month's *AstroNews*.) At right above, part of the telescope's mount is seen as it was removed from the observatory in June. The 100-inch Isaac Newton telescope, currently western Europe's largest, will eventually be surpassed by a planned 165-inch reflector, also to be located on La Palma. Photos courtesy of the Royal Greenwich Observatory.

Rotating Black Holes?

Could the Milky Way Galaxy — in which our solar system is but a tiny speck — change from its quiet, millpond existence into a turbulent, churning dynamo, expelling matter and energy trillions of miles into space? Has it done so in the past? Will it happen again?

Dr. Minas Kafatos of George Mason University (Fairfax, Virginia) and NASA's Goddard Space Flight Center (Greenbelt, Maryland) says such events are possible if his theory that massive rotating black holes, millions or billions of times more massive than the Sun, are causing the enormous release of energy from the centers of active galaxies and quasars.

Quasars themselves are considered mysterious, even baffling, objects. They emit vast amounts of energy and are believed to be the most distant objects observed, some possibly as far away as 10 billion or more light-years, at the very edge of the observable universe.

Recently, radio observations by Drs. Kafatos, R.W. Hobbs, S.P. Maran, and L.W. Brown of Goddard, have shown that the central component of Cygnus A, a "nearby" radio galaxy some billion light-years away which puts out as much energy in radio waves as a hundred billion suns would emit in visible light, is similar in many respects to quasars.

The theory that there are massive black holes at the centers of active galaxies or quasars isn't new, but the concept that the black holes powering the active nuclei are rotating is new.

Kafatos says that it is theoretically possible to extract energy from the region surrounding the black hole, called the ergosphere, by processes known in the theory of general relativity as "Penrose processes." According to this idea, matter falling toward the surface of the rotating black hole can break up, with one portion being injected into the black hole and never emerging, while

the other portion would fly out with more energy than the total object had when it entered the ergosphere.

The energy it gains is transferred from the rotational energy of the black hole. In effect, the matter ejected gains energy by slowing down the spinning of the black hole. The spinning process depends critically on the black hole rotating rapidly enough.

Kafatos and Darryl Leiter of George Mason University recently studied Penrose processes involving elementary particles in the ergospheres of what they believe are rotating black holes. What is required in these processes is a supply of very high energy light waves, known as gamma rays, entering the ergosphere.

The results of the theory proposed by Kafatos and Leiter can be summarized as follows: The gamma rays enter the ergosphere, slam into the protons, and become electrons and positrons. The two new particles then are picked up by the rotation of the black hole. The proton is sucked down into the black hole, never to return, while

the electron and positron are ejected by the rotation with much more energy than the original gamma ray possessed.

The details of the theory are under study by Kafatos. The Penrose processes are continuous, with matter and gamma rays bombarding the swirling hole, detaching energy and streaking out of the galaxy.

The gamma rays are formed by the very hot accretion disk of swirling gases that form around the hole. However, there must be sufficient gaseous mass available in the galaxy to continue the process, otherwise the black holes, like gigantic vacuum cleaners in space, would empty the center of the galaxy of the material necessary to cause violent activity in the galaxy.

"Energy extraction would become inefficient once the gas falling into the black hole becomes depleted or the spin of the black hole is reduced," says Kafatos; "that's why we observe the most violent events in the distant past, billions of light-years away from Earth, because in those early days of the universe there was more gaseous mass available."

Three active galaxies, including a radio galaxy and quasar 3C 273 (famous because of its brightness and variability) have been examined by Kafatos via data received from radio astronomy telescopes and from NASA's Small Astronomy Satellite-2 (SAS-2), launched in 1972. The Kafatos studies indicate the theory of the Penrose processes may be correct. All of these galaxies emit a majority of their energy in gamma rays, a surprise in view of the fact that it is very difficult to produce gamma rays in nature. In addition, the three active galaxies examined radiate radio waves as predicted by the theory.

Kafatos expects the theory can be confirmed in the early 1980s when the NASA Gamma Ray Observatory is placed in orbit by the Space Shuttle. Present spacecraft are not sufficiently advanced to "look" far enough into space at other active galaxies or quasars.

The theory also explains the relative inactivity of nearby normal galaxies. But even they could flare up if sufficient gaseous material were found, for example, by a chance breakup of a cluster of thousands of stars near the black hole. The gaseous material could then be drawn

into the middle of the galaxy by the massive black hole which would cause the nucleus of the galaxy to explode with activity. Such an event could happen to any normal galaxy containing a

massive black hole.

"Maybe our own Milky Way Galaxy flared up like that millions of years ago as a result of such a chance event. In fact, it could flare up again in the future." ☛

Largest Infrared Telescope

A new 3.8 m United Kingdom Infrared Telescope (UKIRT) was dedicated in Hawaii on October 10. The largest infrared telescope in the world, it is one of four large telescopes on the summit of Mauna Kea. The others are: the 2.2 m telescope of the Institute of Astronomy of the University of Hawaii, which has been in operation for some years; the 3.0 m Infrared Telescope Facility (IRTF) of the U.S. National Aeronautics and Space Administration, opened on July 6, 1979; and the 3.6 m Canada-France-Hawaii Telescope (CFHT), which commenced operations on September 28.

Several novel features are incorporated in UKIRT, notably its thin mirror which has a diameter-to-thickness ratio of 16:1. Conventionally, the ratio would be 6:1. In terms of aperture, UKIRT is the largest of the four telescopes on the island, but in terms of the support structure and building, it is the smallest and the least expensive.

With erection and commissioning nearing completion at the 4200 m altitude site, the operational phase is beginning. This will be extended eventually to include daytime as well as nighttime observations. Although designed primarily for use in the infrared (through provision of a chopping secondary mirror, efficient cryogenically cooled detector systems and the

reduction of background emission), the telescope can also be used at visible wavelengths.

In recent years developments in observational infrared astronomy have paralleled advances made in other regions of the spectrum. New sources of radiation have been discovered and new mechanisms have been postulated to explain the physical processes that take place in distant regions.

There have been some unexpected results. For example, the nuclei of galaxies emit unexpectedly large amounts of infrared energy. Exactly what powers these prodigious sources of radiation is as yet unknown. Then there are the massive clouds of interstellar gas and dust which are the sites of star formation. The solid matter provides the surface on which hydrogen and other molecules form, and of the 50 or so different types of molecules identified so far, all have specific absorptions or emissions at infrared or radio frequencies. Only ten years ago such a complex array of interstellar molecular processes was completely unsuspected.

Astronomers may also obtain a new galactic distance scale by correlating infrared, dust-free magnitudes with measured velocity differences. These are some of the fundamental areas in which UKIRT will help astronomy. ☛

Galactic Secrets Sought

So-called "emission-line galaxies," whose spectra are characterized by the presence of bright lines at certain wavelengths, are the strongest sources of X-radiation in the universe. These highly energetic galaxies contain a mysterious source of exceptional power which has not

yet been identified.

Over the next two years, a Pennsylvania State University astronomer will study more than 1000 of these unusually energetic galaxies in a unique search for the source of their extraordinary power. Dr. Daniel W. Weedman, aided by Vicki Balzano, a doctoral

candidate, and partially funded by the National Science Foundation, will examine each of the galaxies using the university's new 62-inch telescope. After eliminating galaxies whose energy output can be explained by ordinary processes, Dr. Weedman will concentrate on the remainder, continuing the work at a national observatory.

The source of the galaxies' energy, Dr. Weedman says, seems related to that in quasars — super-energetic objects generally believed to be the most distant in the universe, farther away than the most distant galaxies. Weedman has previously demonstrated similarities between quasars and the centers of energetic galaxies, and believes their energy sources could be the same.

The best explanation for the power pouring out of these two types of objects, according to Dr. Weedman, is a black hole. Although no one can "see" a black hole, because no light can escape from it, its presence can be deduced from the events surrounding it. For example, as a black hole sucks matter into oblivion, it should give off intense radiation.

Pointing out that no

astronomer has directly observed such a chain of events, Dr. Weedman states that three bits of evidence make it seem likely that such events are in fact taking place in quasars and the highly energetic emission-line galaxies. "First," he says, "more energy comes out of quasars and these galaxies than can be explained by any other process. Second, the energy comes out in bursts, and it's unprecedented for something that bright to flicker. The energy source must be small and localized, like a black hole, since a big source can't change rapidly. Third, the basic properties of the energy coming out — the specific 'fingerprint' of the radiation — points to a black hole as the source."

"Nevertheless," Dr. Weedman adds, "I'm not absolutely convinced that a black hole is the energy source for these things — even though I can't offer an alternative explanation." The energy source could turn out to be something totally unknown. It's important to resolve this mystery because the answer might mean scientists are fundamentally wrong about the nature of physical processes. ☛

THE MESSIER ALBUM

JOHN H. MALLAS and EVERED KREIMER

Owen Gingerich, Editor

A beautifully illustrated volume enabling the amateur astronomer with basic equipment to find and view 100 of the best known nebulae and clusters. Co-published with Sky Publishing, *The Messier Album* includes 30 color and 300 black & white photographs. \$11.95

SPACE AND TIME IN THE MODERN UNIVERSE

P.C.W. DAVIES

"Using no mathematics at all, the author is able to define, explain, and discuss with extraordinary clarity some of the jazziest of contemporary concepts. . . ."

—*American Scientist*

Hardcover \$23.95 Paper \$7.95

ACTIVE GALACTIC NUCLEI

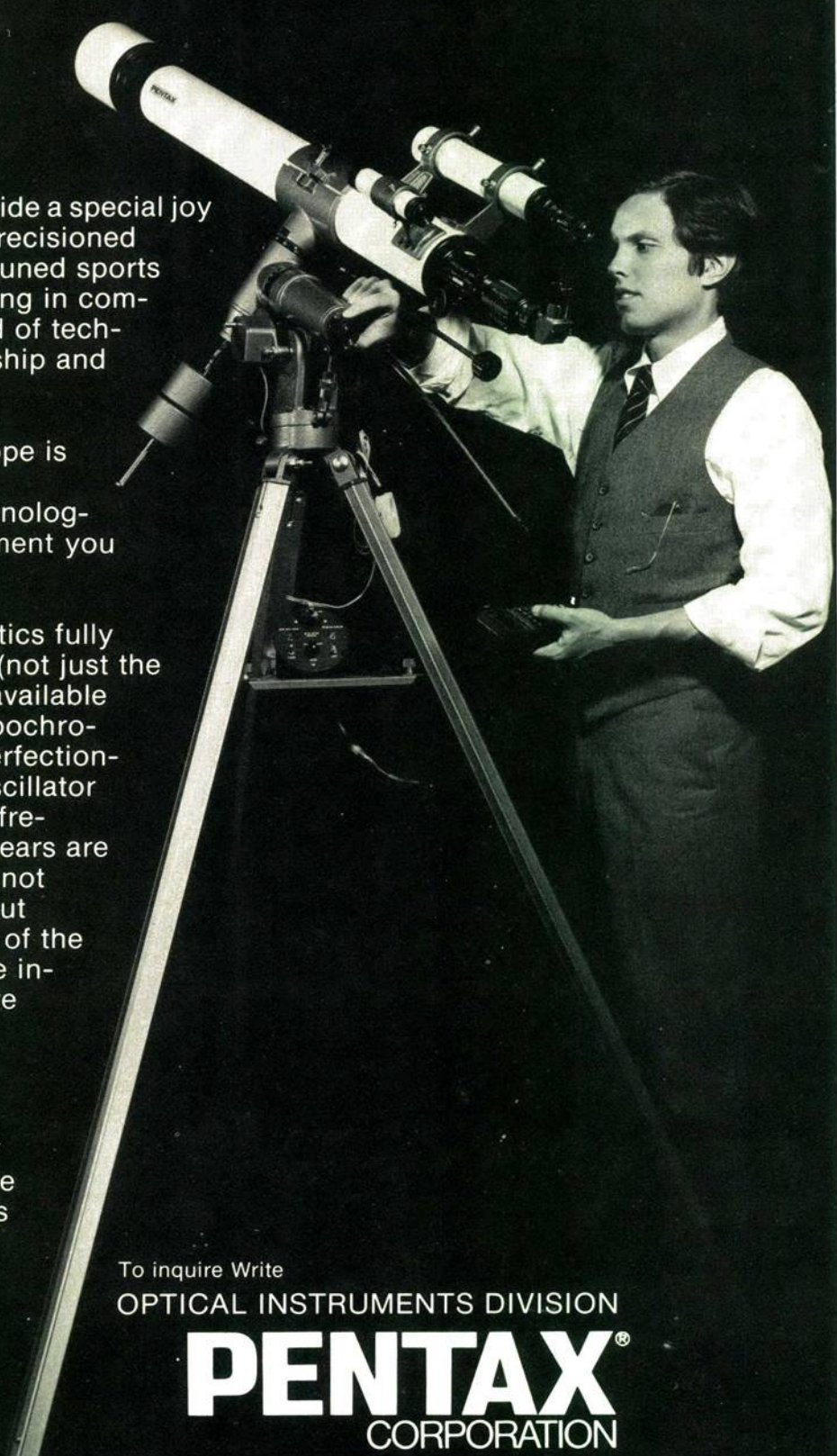
CYRIL HAZARD and SIMON MITTON, Editors

Twelve leading researchers summarize the main theoretical ideas that have emerged from the investigation of excited galaxies and quasars. \$32.50



Cambridge University Press

32 East 57th Street, New York, N.Y. 10022



Some things in life provide a special joy and pride, like a well-precisioned chronometer or finely tuned sports car. Both have something in common—the special blend of technology, fine craftsmanship and functional design.

The Pentax 100 telescope is of this rare breed. It is possibly the most technologically advanced instrument you will ever experience.

The Pentax 100 has optics fully coated on all surfaces (not just the fourth surface) and is available with a three element apochromat for the absolute perfectionist. Its quartz crystal oscillator keeps perfect tracking frequency and the drive gears are fully enclosed so as to not catch dirt and grime. But most of all note the tip of the polar axis housing—the indexed eyepiece will give you exact and instant polar-axis adjustment.

Many other features of this telescope make it the one and only choice for you. Put your hands on the controls of a Pentax 100. Then, and only then, can you appreciate the best.

To Inquire Write

OPTICAL INSTRUMENTS DIVISION

PENTAX[®]
CORPORATION

#9 Inverness Drive East
Englewood, Colorado 80112

Dealers Inquiries Welcomed

THE VALUE OF LIGHT EFFICIENCY

SPECIAL NOTICE

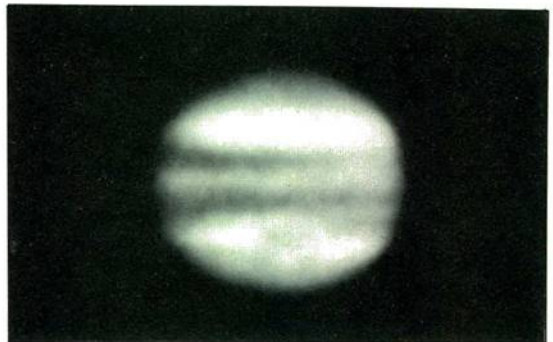
From now until January 1, 1980, we offer the valuable and effective enhanced silver coatings in a special package deal as follows:

Order a Quantum Four with the Modified Davis and Sanford Model B Tripod, and you may have the Special Coatings for just \$20.00 additional.

Purchase the Quantum Six with the Folding Tripod and Wedge, and the Special Coatings cost only \$35.00 extra.

Wide and enthusiastic acceptance of the Maksutov system with its meniscus (dish shaped) corrector lens has resulted from the improvement in outdoor performance it offers compared to the open ended reflector. Closure of the tube by the corrector steadies the air within, protects the internal optics from dirt and insects, and allows a central metallized area on the lens itself to form the Cassegrain secondary; which eliminates the diffraction effects caused by the vanes needed to mount the secondary in the open layout; and last and just as important, the corrector affords the potential for considerable increase in the extent of the diffraction limited field.

Of course, introduction of even an anti-reflection coated lens takes away around 4% of the light; and taking into account the losses on the primary and secondary mirrors plus the star diagonal usually employed, an aluminized Catadioptric Cassegrain telescope transmits 61% to 63% of the light entering it. However, the modern technology that has given us improved imagery can also retrieve most of the light via enhancement of the metal coatings. This consists of deposition of a hard overcoat of a high refractive index material in a closely controlled thickness to accomplish two useful things; First, it protects the metal beneath against tarnish or cleaning abrasion, and second, the monitored depth of the film exploits the wave nature of light to bring the reflected wave fronts from the coating and overlayer together in phase like the low frequency radiation from the woofer cone and port in a base reflex speaker enclosure. The reinforcement boosts the output over the 1/2 octave of interest in both cases (400 to 600 nanometers for the mirror and 40 to 60 Hz for the woofer). Silver is preferable to aluminum for enhancement, due to its greater initial reflectivity over the range for which the overlayer gets tuned in a visual system; and when applied to the primary, secondary, and diagonal, the process increases the efficiency of a Maksutov Cassegrain to 80% or better over the entire visible region, which approaches that of an equal aperture doublet refractor objective. The disadvantage of the refractor objective is the curtailed diffraction limited bandwidth caused by inherent chromatic aberration.



This photograph of Jupiter was taken in February of 1979 on H and W-VTE film with an exposure of 4 seconds. Noteworthy are the faded condition of the Red Spot, the bright oval in conjunction with it, and festoons in the Equatorial zone. No photograph, however fine, shows what the eye could have seen at that moment. Jupiter will reach opposition in late February 1980!



QUANTUM SIX AT \$1995.00

QUANTUM FOUR AT \$1085.00

The effective union of superb design with conscientious workmanship has earned for the Quantum series an enviable reputation for unsurpassed performance in all instances that challenge the optics of a telescope. If you have any questions or would like to learn more about these fine instruments, you are invited to send for our free literature and discuss your concerns with us.

OPTICAL TECHNIQUES, INC.

205 Pheasant Run, Dept. AM, Newtown, Pa. 18940
(215) 968-4739

Eastern Representative:

Rodger W. Gordon
637 Jacobsburg Rd.
Nazareth, Pa. 18064
215-759-6805

Midwestern Representative:

James P. Skinner
3838 West 107th Place
Chicago, Illinois 60655
312-779-8945

Western Representative:

Leo C. Henzl, Jr.
P.O. Box 6038
Rolling Hills, California 90274
213-541-4331

READER ALERT!

WE'VE DONE IT!

ASTRO-ENGINEERING was originally conceived with the idea of making available to the astronomy market **Celestron** products at the **LOWEST PRICE** to be found anywhere. This all came about because of a void in the astronomy market while trying to find a dealer we could trust and afford. This was the beginning of **ASTRO-ENGINEERING**, September 28, 1978, a company formed with you in mind.

WHY BUY YOUR CELESTRON FROM US?

1. High Volume = Low Prices. We prefer to make a little money on a lot of scopes and accessories.
2. All **Celestron** products we sell are inspected for mechanical and optical performance. We guarantee every product will meet or exceed factory specifications when you receive it.
3. All products are shipped from stock for fast delivery. **Celestron** scopes are shipped from our Torrance facility approximately 1 mile from the **Celestron** Factory.
4. Your Satisfaction is Guaranteed because we're not satisfied until you are.

MOON FILTER

See the moon as you've never seen it before!

First filter of its kind. This type of filter is not to be confused with smoked or colored glass and shade filters which do not preserve image quality and color rendition. The Moon Filter is a precision Neutral Density filter that attenuates the Lunar intensity uniformly over the visual spectrum (4½ stops or 5% T). This allows the eye to become dark adapted thus enabling the pupil to open up and see finer Lunar details.

The optically flat substrate is coated with an evaporated inconel alloy that produces a 1.3 optical density mirror-like surface. A BK-7 optical window is employed due to its unusually good optical properties (the same material used in Bubble Chamber windows).

Each filter comes with its own individual optical density trace from UV-IR.

MF-3 1¼" Thread-in filter \$29.95

NEBULAE FILTER — TOTALLY NEW AND IMPROVED

The design of our new Nebulae filter was built on the idea of what a nebula filter was originally conceived to do. Our new Nebulae Filter is setting new standards in the Nebula Filter industry with its ultra-narrow transmission windows creating a much darker sky than was previously possible. This was accomplished while maintaining extremely high transmission of Nebular light (H-beta 486.1, Doubly Ionized Oxygen - OIII 495.9/500.7, H-alpha 656.3, Nitrogen 654.8/658.4). Since most cities are converting to High Pressure Sodium and Deluxe Mercury Vapor streetlights with broad transmission lines we took special care during the designing process to block these sky polluting lines. To reduce film fogging during astro-photography even in the country our filters totally block Natural Sky Glow caused by OI emissions. Our new filters are fabricated by using an all dielectric approach to achieve the required Fast Rise Time, Narrow Bandwidth, High Nebular transmission, Extremely Large Integrated Blocking Ratio. The coatings are sandwiched between two optically flat substrates, and hermetically sealed and edge protected by two anodized rings; this more than doubles the life of a standard filter. To complement this we bond the filter into a black anodized cell, threaded for standard 1¼" oculars. (For extremely narrow band, research type observing, see our Precision Line Filters).

FA — Filter Adaptor for non-standard 1¼" oculars \$10.00

NF-3 — 1¼" Thread-in filter \$49.95

(Dec. 10th price \$59.95)

UNCONDITIONAL 60 DAY MONEY-BACK GUARANTEE — 3 YEAR WARRANTY

PRECISION LINE FILTERS

These single channel filters are not to be confused with common Nebulae Filters; these precision line filters will single out and isolate an extremely narrow region of the spectrum due to their Ultra-Narrow bandwidth design. Gaseous emission nebulae take on completely different shapes when viewing only the discrete transmission line of Oxygen or Hydrogen light. The filter bandwidths are wide enough not to attenuate Doppler shifted nebulae. The H-alpha filter has a bandwidth of 100 angstroms which is sufficiently wide enough to transmit the two adjacent Nitrogen lines. The Integrated Blocking ratio (Contrast ratio) is so large that Mercury, Sodium, Tungsten, and Lunar light pollution is essentially eliminated; the nebula is embedded in an absolutely BLACK sky. The precision line filters have their coatings sandwiched between two optically flat substrates and hermetically sealed to protect the coatings from the environment. Each filter comes with its own individual transmission curve and color coded case.

Ha-3 Hydrogen-alpha 6563, Thread-in 1¼" \$119.95
 OX-3 Oxygen OIII 5007, Thread-in 1¼" \$119.95
 Hb-3 Hydrogen-beta 4861, Thread-in 1¼" \$119.95



Keep your Celestron Scope in new condition with Celestron touch-up paint. The two vials contain 10cc of grey-brown and orange touch-up paint.

2 Vials Touch-up Paint \$5.00

ASTRO-ENGINEERING

2706 Harbor Blvd. □ Costa Mesa, CA 92626 □ 714/549-4705

CLOCK DRIVE & DEC. BEARING LUBRICANT

TRI-FLON is a new synthesized lubricant that reduces clock drive vibrations due to eccentricity of the worm gear and inexact gear facing. **TRI-FLON** contains micron-size TEFLON[®] particles, that dramatically decrease friction and wear. **TRI-FLON's** boundary film displaces moisture, dirt, dust, prevents icing, inhibits the formation of rust. **TRI-FLON's** low viscosity penetrates areas normally inaccessible to other lubricants. **TRI-FLON** dissolves and prevents carbon deposits, sludge, crystalline structures formed by moisture and salts. Temp. range: -65°F to 475°F.

TRI-1 90 gram Spray Can, ext. nozzle \$3.00

TRI-5 450 gram Spray Can, ext. nozzle \$6.00

TRI-7 15cc Squeeze Bottle \$1.00

*TEFLON — Registered trademark of E.I. Du Pont de Nemours & Co.

ORDER EARLY FOR CHRISTMAS

.....

☐ NF-3 .. \$49.95

☐ Ha-3 .. \$119.95 Name _____

☐ OX-3 .. \$119.95

☐ Hb-3 .. \$119.95 Address _____

☐ MF-3 .. \$29.95

☐ FA \$10.00 City _____

☐ Paint .. \$5.00

☐ TRI-1 .. \$3.00 State _____ Zip _____

☐ TRI-5 .. \$6.00 ☐ VISA ☐ M/C ☐ C.O.D. ☐ Check, M.O.

☐ TRI-7 .. \$1.00

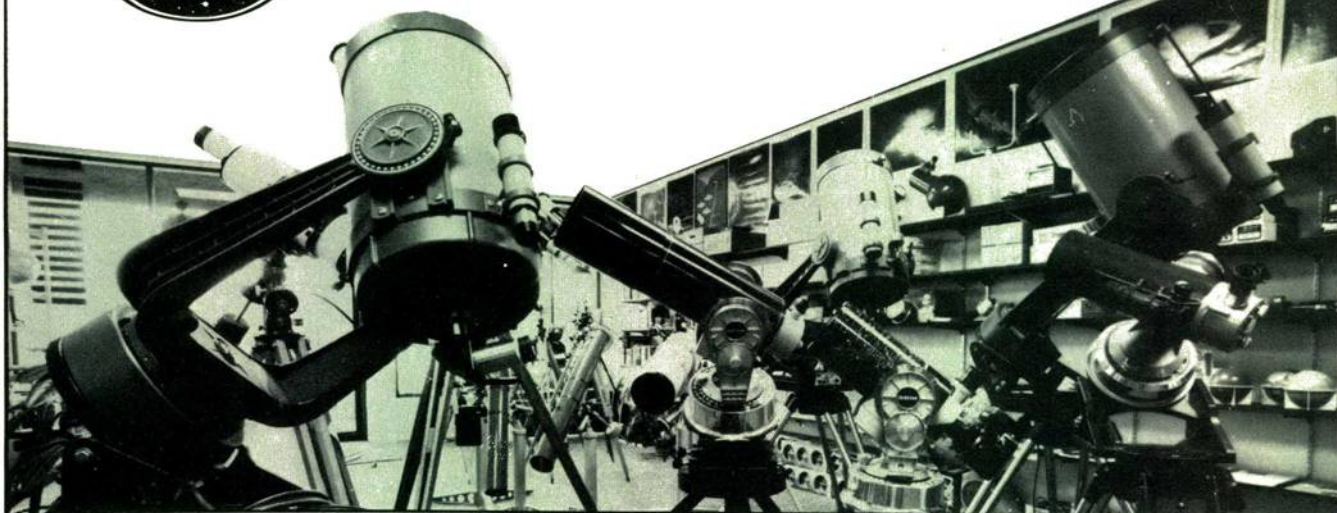
☐ Free Info Card No. _____

☐ \$3. Catalog Package, includes Signature _____

☐ Celestron & Meade Catalogs, etc.



— “this is it...”

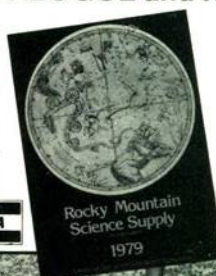


THE WORLD'S FINEST TELESCOPE CATALOGUE and REFERENCE MANUAL

Because we alone sell and service most MAJOR LINES of telescopes made today, we do not favor one instrument over any other. We provide no gimmicks, certifications, or free accessories of doubtful value. NO MAGIC, just quality service.

You will be dealing with people who frequently visit the manufacturers — and they visit us!

You can compare Celestron, Quantum, Edmund, Questar, Meade, Star, Unitron SIDE BY SIDE IN OUR SHOWROOM or AS SHOWN IN OUR NEW 80-PAGE CATALOGUE. Includes thousands of eyepieces, photographic accessories, drives, filters, focusers, cells, finders, binoculars, books, star charts. All this, and plenty more, has been carefully selected to eliminate any second quality products.



OUR CATALOGUE INCLUDES TELESCOPE SELECTION GUIDES, EYEPIECE GUIDES, OPTICAL MAINTENANCE PROCEDURES, AND ASTRO-PHOTOS INCLUDING THE 1979 SOLAR ECLIPSE!

SEND \$2.00 CASH, CHECK, OR MONEY ORDER TODAY TO

the STAR TRACKER

3093 Walnut St., Dept. AS, Boulder, CO 80301
or call (303) 442-6805

New From Astronomy

NASA celebrates our first true space ship with this enormous 30x42" poster featuring a large fully detailed cutaway drawing of the shuttle itself. The full color rendering reveals every inner working of the craft, right down to the fuel pipes in the engine. Also included are a complete description and specifications. This is one of the best NASA pieces we've seen, one that every space enthusiast will want on their wall. In stock for quick delivery, the poster will be shipped folded as received from NASA.

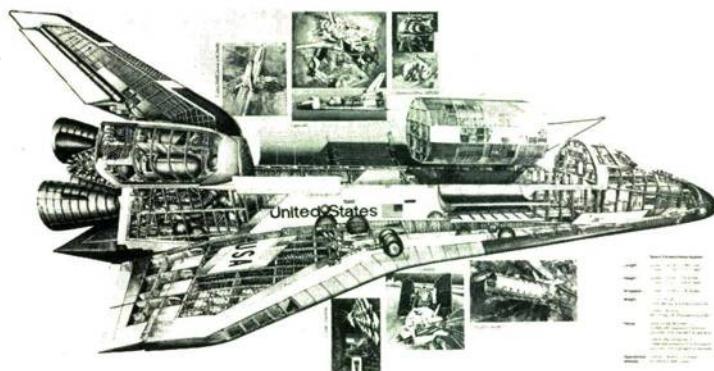
\$3.25



To order use form bound into this magazine.

Inside The Space Shuttle

Space Shuttle



NASA Facts

Space Shuttle

1979




Odyssey

THE YOUNG PEOPLE'S MAGAZINE OF ASTRONOMY AND OUTER SPACE

THIS CHRISTMAS GIVE THEM THE STARS

GIVE THEM ODYSSEY, THE FIRST
AND ONLY ASTRONOMY AND
OUTER SPACE MAGAZINE JUST
FOR KIDS!

SPECIAL 1/2 PRICE OFFER

Give one gift subscription at regular
price, all other gifts are 1/2 price!
Every child gets a gift announce-
ment card and membership card in
Odyssey Club!

ASK ULYSSES

Got a question about the universe?
Get an answer from your favorite robot!



FREE

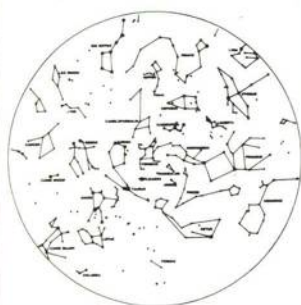
Every child receiving a
subscription will get a giant
22"x34" Antares poster worth
\$3.95 absolutely free!

Use order form attached or mail to:
AstraMedia Corp. 411 E. Mason St.,
Milwaukee, WI 53202

THE THOROUGHLY MAGNIFICENT RICHARD AND ROBERT SHOW

Odyssey CLUB

Send Ulysses a drawing! You may see it in
print!

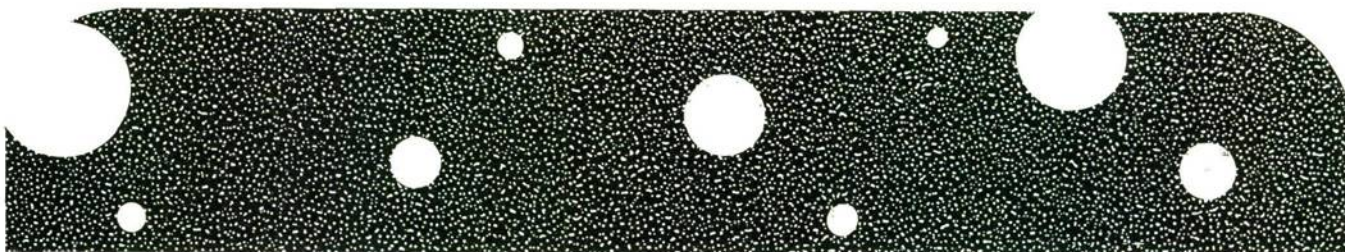


★★★★★ all-stars

The "Inside" story of the constellations — gods & heroes,
stars, galaxies, clusters, nebulae!

FIND THE STARS... ...AND THE PLANETS

Complete with star map and colorful drawings.



STELLAR FRONTIERS

Mass Loss from Stars

by
Robert E. Stencel

Visually, the Sun appears to have a sharp circular edge. Its symmetry, along with that of the Moon and the circular motions of the planets and stars, gave rise to the pre-Copernican notion of the perfection of celestial bodies. Occasional reports of sunspots seen near sunrise or sunset were dismissed by the respectable philosophers, for how could a perfect object be blemished?

Three centuries later, discoveries of radio telescopes and ultraviolet and X-ray satellite observatories revealed that not only was the Sun blemished with spots, but it wasn't even round when seen in other than white light. In the non-visual parts of the electromagnetic spectrum, the Sun appeared blob-like, apparently engulfed in great moving clouds of hot gas. Radio and optical studies quickly demonstrated a correlation between solar storms, the occurrence of aurorae in Earth's atmosphere, and disruptions in long-distance communications. The Earth, it seemed, was bathed in an outgassing of matter from the Sun itself. Later, satellite work verified this.

The Earth captures enough solar material to sustain the van Allen radiation belts which are caused by passing solar-charged particles being caught by the Earth's magnetic field. This outflow of material, moving at some 400 kilometers per second, is called the *solar wind*, and it causes a loss of some ten million tons of material from the Sun each year. Although this sounds like a huge amount, it's only one one-hundred-million-millionth (10^{-14}) of the Sun's mass; at such a rate, only 0.01% of its mass would be lost during the Sun's ten billion year lifetime. Accounting for the acceleration of this material into space at the observed speeds posed a difficult and complex problem for solar physicists. In developing an attack on the problem, it wasn't long before they began to wonder whether other stars might possess *stellar winds* comparable to the Sun's.

Main Sequence Atmospheres

Stars spend the bulk of their lifetime on the *main sequence*. Any discussion of mass loss, therefore, necessarily involves main sequence stars — those which derive their luminosity from the fusion of hydrogen into helium in their cores.

The main sequence is fundamentally ordered by a star's mass. The hottest and bluest stars are the most massive. The gravitational fields generated in these huge stars lead to high central temperatures and pressures. In such extreme environments, the most energetic forms of thermonuclear fusion can take place, producing stars that emit great amounts of energy and have high intrinsic brightness. The most massive stars, those in the upper main sequence, have convective centers and radiative

envelopes due to their high-energy thermonuclear processes. (See "Stellar Evolution," *ASTRONOMY*, February 1979, for background information on stellar structure and evolution.)

Lower main sequence stars like the Sun, with their milder central conditions, possess a radiative core region and a convective envelope. This major structural difference, now partially understood by astronomers, must lead to differences in the atmospheric structure as well. But our present knowledge of the outer atmospheres of stars is still based largely on chains of deductions from scant observational data. The wavelengths that carry vital clues to astronomers don't penetrate our atmosphere. Only now, with UV and X-ray data becoming available from recent satellites (especially IUE and HEAO), is progress in this area truly taking place.

We now know that upper main sequence stars have their atmospheric structure dominated by radiation pressure. The very hottest, for example, are O-type stars. Their effective atmospheric temperatures range above 25,000° Kelvin, and they have luminosities in excess of 10,000 times that of the Sun. The pressure exerted by energetic photons (i.e., light) is sufficient to not only lift the gas above the photosphere away from the star, but to drive it off into space at speeds up to thousands of kilometers per second. This process can also impart enormous turbulence to the local interstellar medium, evident in the swirls of the nebulae surrounding hot blue stars such as the Orion and Lagoon Nebulae.

The flow of material away from a star may be as much as 0.0001 solar mass per year in extreme cases. At this rate it would take only a quick million years for a star, even a massive one, to lose its original 20 to 50 solar masses. Evolutionary effects keep these stars from fully "evaporating," but the very course of their evolution is determined by this mass-shedding phenomenon and by the local interstellar medium.

The hot B and A-type stars — less massive, less luminous, but more numerous — appear to have a similar but far less vigorous radiation-driven outflow of material.

In contrast, the lower main sequence stars are sedate. Their effective atmospheric temperatures are much lower than those of the O and B stars, and they would be

NGC-7635 (the Bubble Nebula) is a curious wisp of gas surrounding an 8th magnitude star in Cassiopeia. Sometimes referred to as a planetary nebula, it doesn't resemble many of them very much. More likely it's a diffuse cloud of neutral gas shining by reflected light. Jack Newton photograph.



unable to drive off material by radiation pressure alone. However, the convective envelope of cooler stars provides a setting for shock waves and powerful acoustic "noise." (See "Between Stars and Space," *ASTRONOMY*, September 1977.) Combined with the rapid decrease in density outward from the star, energetic sound waves not only can blast material away from the star's atmosphere, but also heat it to temperatures of millions of degrees.

Our Sun's corona, which we tacitly regard as archetypal, has been examined in great detail. The Sun is, after all, the most convenient star, and its proximity enables us to resolve a wealth of surface detail. Time-lapse films in visible light show astronomers the unceasing, turbulent motions in the *photosphere*, the outer layer of the Sun proper. Ultraviolet and X-ray spectra, especially those from Skylab and the OSO (Orbiting Solar Observatory), show that activity extends upwards through the atmosphere into the corona. There, tremendous blobs of thin, superhot plasma are bottled by sun-sized magnetic loops. Frequently the force of the turbulence from below is sufficient to stretch and burst the weak magnetic confinement, scattering the released material away from the Sun.

This flow is part of the solar wind. It measures about 10^{-14} solar masses per year, a trifling one-hundred-millionth of the stellar wind of an O star. In other solar-like, lower main sequence stars, the preponderance of current evidence points toward a situation similar to the Sun's: a highly turbulent atmosphere enveloped in hot, thin coronal gas, blowing off a light stellar breeze.

Evolved Star Atmospheres

Stars which shine by the thermonuclear fusion of hydrogen into helium ultimately find themselves faced with an energy crisis as their interior hydrogen fuel supply dwindles to a level where nuclear reactions can no longer be sustained.

In a main sequence star, the reactions in the core go on at a leisurely rate; the star is snugly condensed, and shines at a relatively low luminosity. Upon running low on hydrogen, events take place which radically alter the star's external appearance and overall stellar structure. The distribution of mass with respect to radius, the fundamental parameter of stellar structure, depends on the balance of gravity (forcing matter inward) and the pressure of gas and radiation (forcing matter outward). Turning off the central energy source gives gravity the upper hand, and the star begins to change.

As the energy source at the core sputters and fails, gravity begins to overwhelm the radiation pressure. The core and the central regions of the star collapse inward. The infall releases gravitational potential energy sufficient to make the outer half of the star's matter swell outward. In its new configuration, the radius of the star may be hundreds of times what it was before, and the star can be appropriately renamed a "giant."

In the course of this transformation, the atmospheric temperature drops from perhaps $10,000^\circ\text{K}$ to as low as 2500°K . The cooler surface no longer emits as much light and heat per unit area, but because of the increase in surface area, the total luminosity of the star may actually increase. Indeed, the brightness of the star may increase by thousands of times over a period of only a few tens of thousands of years.

A significant transition, only recently discovered, occurs in the stellar atmosphere as stars become giants. The main sequence atmosphere includes a hot corona and light stellar "breeze." As the star evolves, its corona dissipates and the breeze turns into a strong wind, with as much as an entire solar mass being blown off over the course of the next million years.

The abruptness of the change from corona to mass-loss-type star is truly amazing. Giant stars with an effective atmospheric temperature of 4500°K exhibit

spectroscopic evidence for coronal material and no significant stellar wind, whereas those only 250°K cooler — at 4250°K — show no sign of having a hot corona and exhibit strong stellar winds and mass loss.

Although the final explanation for this effect is pending, the best theory proposes that in the unstable thermal regime around $200,000^\circ\text{K}$, radiation losses from the hot gas become so severe that a corona can't maintain that temperature. The gas cannot either heat up to a million degrees (where radiation losses happen to be low) or cool down to $15,000^\circ\text{K}$ (where radiation losses diminish). As stars evolve toward this transition, they switch from being able to sustain a corona into a state where they cannot. Energy no longer being used to heat the corona goes into a vigorous ejection of upper atmosphere material into circumstellar space.

The physics of this segregation between corona-type and strong mass-loss-type stars is so inflexible that it may be related to the apparent scarcity of an entire class of stars called the subgiants. Subgiants, when found, are intermediate in luminosity between giants and main sequence stars. Once a star has evolved across the boundary and into the non-coronal regime, they lose mass rapidly and evolve out of the subgiant region.

Convection persists in the envelopes of evolved giant stars. As with lower main sequence stars, the details are not well determined since stellar surfaces other than the Sun's are impossible to resolve with today's telescopes. Photometric and spectroscopic observations show the surfaces of red giants to be highly turbulent. They suggest a chaotic picture: sun-sized clouds of gas buffeted by shockwaves heating the upper atmosphere and ram-pressuring matter out of the envelope and into the circumstellar environment; waves of stellar material changing state from hot gas to sooty, cold molecules like lampblack carbon, as heat sources vanish in the ever-changing opacity of the extended atmosphere. These convective motions may exceed 50 km/sec — infall, outflow, vast swirls of material — all together with the general mass-loss outflow. Even at distances dozens of stellar radii away from the star, there may be significant densities of material. The most turbulent terrestrial storms — even the mighty storms of Jupiter — fade by comparison to the chaos raging in a giant star's atmosphere.

The energy migrating outward through the envelope from the still-hot core of a giant star powers this violence. Two related physical effects control how this energy creates atmospheric conditions: *convection* and *pulsation*. Convection begins whenever the temperature difference between central and outer regions of the star grows too large for radiation to carry the energy flow alone. Mass motions, literally boiling, help reduce the excess temperature gradient and carry the heat load. Once moving, however, material may overshoot and, on the upward leg, penetrate the surface, giving rise to activity and heating there. On the downward leg, it may penetrate the core, picking up for distribution through the atmosphere heavy elements generated there. The star then appears to astronomers to have abundance anomalies, such as far too much carbon or nitrogen for a normal stellar atmosphere.

Pulsation can have similar effects, although it is distinct from convection. Driven by the energy involved in the ionization of hydrogen or helium, the star swells and then shrinks. If the ionized gas in some layer of the star cools (by expansion, for example), the recombination

The Helix Nebula (NGC-7293) is one of the nearest planetary nebulae. A large shell of gas excited to fluorescence by the powerful radiation of a small, but very hot, central star, the Helix also shows radial structure — a feature unseen in other ringlike planetaries. Hale Observatories photograph.





of ions and electrons releases energy, heating overlying layers. They then expand to some maximum height and recollapse. The gravitational energy of infall reheats and re-ionizes the original layer which later cools and continues the cycle.

Other, more demanding, conditions must be met to establish a stable, long-lasting pulsation of the type seen in long-period, Cepheid, or RR Lyrae variables, and others which exhibit regular periodic fluctuations in brightness that are the signature of pulsation. Impulsive or semi-stable pulsations do not require precise conditions, and can occur in a wider variety of stars, especially among the cooler giants and supergiants. Semi-regular variables like Betelgeuse may be an example of this.

The ultraviolet spectra of both cool K-type stars and hot A-type supergiants suggest that they too undergo sporadic mass-loss, occurring in giant "puffs." Possibly arising from impulsive or even non-radial pulsation, the eruptions resemble a sort of stellar indigestion.

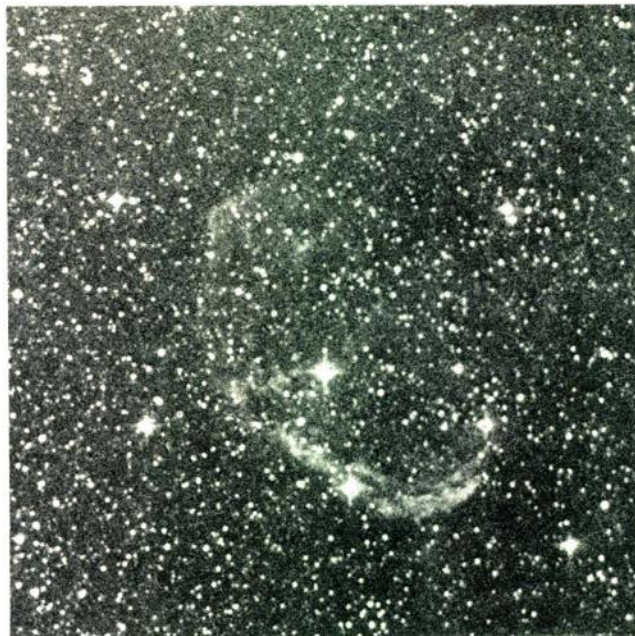
The supergiant stars are qualitatively comparable to the giant stars, only more extreme. They evolve from higher-mass upper main sequence stars and end their careers in spectacular ways, such as supernova explosions. Our knowledge of the evolutionary story of supergiants is rather sketchy, based largely on computer models. Observationally, supergiants make sudden rapid changes from hot to cool and back again. Theoretically, supergiants migrate cool to hot to cool as they use successively heavier nuclear fuels in a wild fling before the inevitable. Part of the rapid temperature variation may be due to brief episodes of very intense mass loss in the atmosphere, while internal variations in the production of energy (sputtering) may also contribute.

Impact of Mass Loss on Stellar Evolution

While the twin processes of pulsation and convection are busy determining the atmospheric structure of an evolved star, interior forces can totally overwhelm them. Stellar evolution is essentially the result of a sequence of thermonuclear reactions that provide stellar luminosity. Stars are formed principally of hydrogen, and as long as the star transforms that material into helium, it lives out its lengthy main sequence lifetime peacefully. When hydrogen is ultimately depleted, the structure of the star is reorganized into the giant or supergiant configuration — compact core and extended envelope — where helium fusion becomes possible. The onset of this, known as the helium flash, is somewhat traumatic for the star. Its core expands and the envelope contracts, heating up slightly. This may also have effects on the atmosphere, but they're not well-known and are being studied.

Three helium nuclei can be fused to form carbon nuclei in a high temperature reaction, but few stars have sufficient mass to provide central temperatures and pressures high enough. There may be times, however, when such fusion is *almost* possible, so the star's nuclear engine may "sputter" to some degree. Intermittent sputters, combined with pulsational instabilities, can lead to partial ejection of the atmosphere and envelope of a red giant. The result, a planetary nebula, is an ring-shaped or helical gas cloud surrounding the central star. (See "Planetary Nebulae," ASTRONOMY, March and April 1979.)

Planetary nebula material is observed to be moving radially away from a central star at speeds up to 50



NGC-6888, sometimes called the Crescent Nebula, is a very massive cloud of gas in the middle of which lies an exceedingly hot, emission-line star weighing about 10 solar masses. Thomas L. Dessert photograph.

km/sec. A massive planetary may contain as much as 0.1% of the star's mass, and persist thousands of years. In a few cases, they're multiple; a newer, compact planetary nebula is embedded within an old, extended, and diffuse one. Exactly when and how often a red giant star performs in this way is unknown, but for stars of a certain mass, the final explosion can lift away the remnants of the cool envelope entirely, revealing the hot condensed core.

The mass lost from stars through planetary nebulae combined with other mass-loss processes such as stellar winds, returns a substantial amount of material to the interstellar environment. The new material will usually differ from the primordial clouds (which are pure hydrogen), and the introduction of helium and heavier elements into the raw material will profoundly affect new generations of stars subsequently formed from that material.

Rate Determines Fate

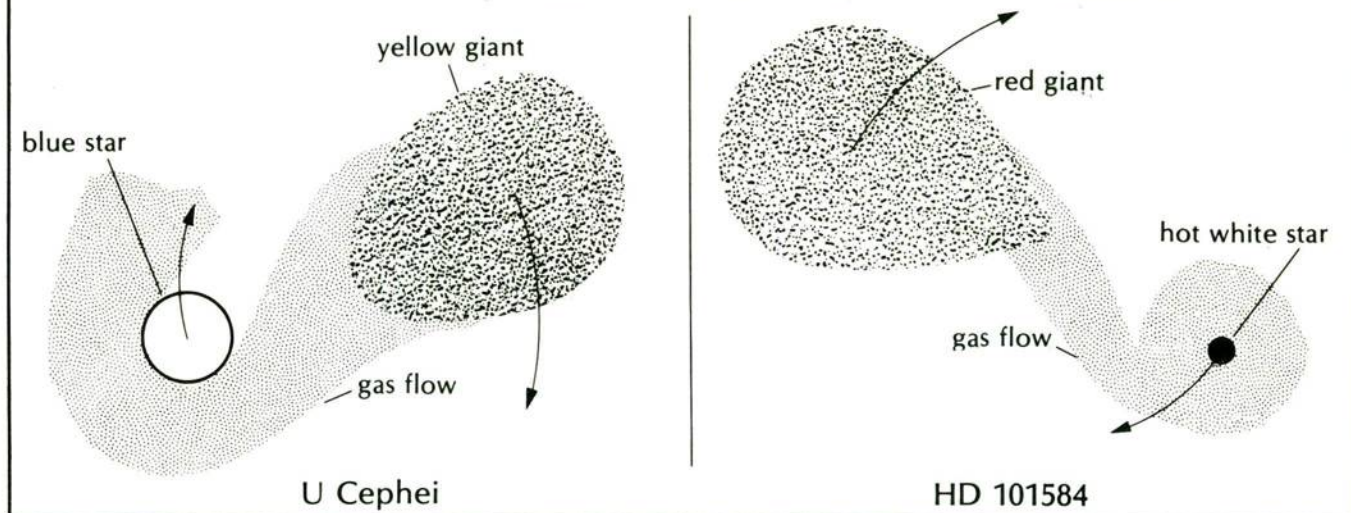
If a star is too massive, it won't be able to retire gracefully as a white dwarf, but instead explodes. The only way for a star to avoid this is to shed bulk through sustained mass loss. In a very direct way, the mass-loss rate determines the fate of stars in advanced stages of stellar evolution. Sufficiently massive stars find that they can go beyond fusing helium into carbon, and continue to shine by fusing carbon into heavier nuclei, and then fuse those heavier nuclei into still heavier material.

If such a star manages to develop a core rich in the element iron before it's lost too much of its mass from pulsational instabilities or core sputtering, then it has set itself up for a most spectacular death: internal collapse triggering a supernova. Objects reaching that stage of existence sometimes find their massive cores implode to a gravitational singularity, or black hole. Slightly less massive stars, or those that have shed enough mass through strong stellar winds, might also experience a supernova explosion, but their cores are unable to pass the singularity threshold, and instead bounce back to the realm of nuclear compression: they become neutron stars.

Much less massive stars, like our Sun, or those

M-27, the Dumbbell Nebula, is the easiest of the planetary nebulae to see in small-aperture telescopes. Seen in the constellation Vulpecula, the Dumbbell is about 900 light-years away. Here again is an ejected shell of gas lit by the fierce radiation of a hot, collapsed central star. Hale Observatories photograph.

MASS FLOW BETWEEN STARS IN BINARY SYSTEMS



capable of shedding enough mass to wind up with less than 1.4 solar masses (the upper limit for white dwarfs), undergo a slow decline via the less violent route of planetary nebula formation.

Stars That Aren't Alone

Probably half or more of all stars are binary or multiple, and many that we think are single may have planets. The study of the effects of mass loss within such binary systems is an exciting field; astronomers had carefully studied it for many years before stellar evolution was even imagined to be a thermonuclear process. Nearly a century ago, observers noticed that certain eclipsing binaries seemed to be increasingly late or early for their predicted eclipses. This was troubling, because precise prediction of the positions of the planets was the bread-and-butter of astronomy, and eclipse predictions were accurate and reliable to many decimal places. Something was gumming up the celestial clockwork.

Binary stars were expected to obey the same universal laws of motion as the planets, and most did. Only by inferring additional material in the binary system could astronomers explain the anomalous behavior. It didn't take much courage to hypothesize extra material, because astronomers knew many of the peculiar systems were close binary stars, suns separated by only a few times their radii. Clearly if one star were losing mass, the other couldn't help but pick up, or accrete, at least part of the matter. With the total mass of the system changing as well as the balance of masses within the system, the period had to change as well.

Modern binary star theory is couched in the language of gravitational dynamics. Astronomers launch test particles into "orbits" — via digital computation — in the vicinity of such stars. As you'd expect, some of the material eventually crashes into the companion star, and hot spots can be formed where it hits. Hot spots are observed on certain types of eclipsing binaries (particularly the RS CVn stars), of which Capella may be an example.

Sometimes the effects of non-steady mass loss in a binary system can become even more spectacular. A binary containing a giant star and a white dwarf can shine out in nova-like brightenings when a strong blast of stellar wind from the giant interrupts clouds of gas orbiting the white dwarf and induces a sudden large

fallout. Accelerating as it falls to the white dwarf's surface, the gas will heat up, giving off X-rays. The X-rays in turn heat the star further, causing a surface thermal runaway which we see as a sudden burst of light from the star — a nova outburst.

In addition to novae, careful photometric and spectroscopic analysis of binary stars reveals numerous situations involving mass loss. Streams of matter which may originate from the mass-losing component orbit around the other star, partly escaping as a spray into space. Stars like U Cephei and perhaps Beta Lyrae are examples of this. When one of the companions starts expanding its envelope as it begins the giant phase, it can impinge on the other. Such pairs, called *contact binaries*, exhibit a bewildering variety of effects, much to the puzzlement of investigating astronomers. Undoubtedly, they evolve differently than isolated stars.

And what of the fate of planets or low-mass stars caught in such an interaction? The increased friction caused by the ejected mass would slow the satellite in its orbit, and would in time lead to a death spiral into the larger star, with messy consequences.

In a general way, the companion to any mass-losing star is bound to find its evolutionary path affected by the accretion of material from the other's stellar wind. The effects, while varied, could lead to novae or supernovae if sufficiently large amounts of matter are added to the mass of the companion.

Why is mass loss important and why are astronomers avid to learn more about it? Clearly, the life histories of stars are altered significantly; single stars don't follow the obvious evolutionary paths because they're losing their surface layers. Binaries become far more interesting than simple pairs of single stars circling one another; they become systems that can interact in thousands of different ways, losing, gaining, and exchanging mass. And where does it all go, the mass that's lost? Into interstellar space, loaded with nuclei from the cores of stars, there to enrich the interstellar medium and make another generation of stars. ☛

*Robert Stencel is an astrophysicist at NASA's Goddard Space Flight Center, Greenbelt, Maryland. His professional interests are in the fields of stellar atmospheres and late stellar evolution; his last article in *ASTRONOMY* was "Astronomical Spectroscopy" in the June 1978 issue.*

ASTRO-MART

Astro-Mart is a free service department available to all our readers. No subscription is necessary to place an ad, but we can allow only 2 noncommercial ads per person per year. You are limited to 40 words including your name and address. All ads are, of course, subject to editorial review for suitability. Be sure to allow 4-6 months for your ad to appear. AstroMedia assumes no responsibility for statements made in classified ads, nor for the quality of advertised items. We cannot acknowledge classified orders nor provide checking copies.

ADVERTISER INDEX

ADVERTISER	PAGE
Astro-Engineering	75
Astro-Murals	91
Astro Technics	87
Astronomical Unit	42
Astronomy Book Club	65
Beattie, John	91
Bost Products	91
C&G Enterprises	87
Cambridge Press	72
Celestron International	32,33,100
Cisneros, Eugene	85
Coast Navigation School	87
Cole Energy Systems	86
Colonial Optical Co.	91
Coulter Optical	85
Criterion Mfg. Co.	41
E&W Optical	87
Eastern States Distributors	90
Edmund Scientific Co.	2
Efstonscience	90
Farquhar Globes	64
47th St. Photo	88
Hansen Planetarium	85
Hirsch, Edwin	89
Hume, Elliott	87
Luft, Herbert	91
Manasek, G.B.	87
Meade Instruments	50,51
Meyers, B.E.	86
Mobile Telescope Sales	87
Model Haven	87
Nega-File	60
Omni Optiks	90
Optica b/c	88
Optical Techniques	74
Orion Telescope Center	49
Ottewell, Guy	61
Pentax Corp.	73
Potter Sales	88
Prime Tours	89
Rolex	31
S&S Optika	27
Science '80	25
Self-Realization Fellowship	90
Sky Scientific	90
St. Clair, Rothschild & Co.	29
Star-Liner	29
Starloc	88
Startracker	76
Texas Nautical Supply	89
Tuthill, Roger	66,67
Vantage Press	87
Vintage Books	87
Voyager Image	88
Wacks	90
John Wiley & Sons	57
Woodstock Products	89

COULTER'S OPTICAL MART "THE WORLD'S GREATEST VALUES IN OPTICS FOR ASTRONOMY"

Send for our price list of exciting values in astronomical mirrors, Cassegrain optics, elliptical diagonals, kits and telescopes.

EXAMPLES:

4-1/4" RFT Kits \$34.50 ppd USA
6" F8 astronomical
mirrors \$39.95 ppd USA
8" F7 astronomical
mirrors \$69.95 ppd USA
12-1/2" F6 astronomical
mirrors \$199.50 ppd USA
Space age 4-1/4" CT-100
Telescope w/o accessories.. \$79.50 ppd
Write or phone for detailed information.

COULTER OPTICAL COMPANY BOX K
IDYLLWILD, CALIF. 92349 Phone 1-714-659-2991

YOU CANNOT AFFORD TO BUY A CELESTRON

Without Calling Us For The
Most Competitive Prices
To Be Found Anywhere
SPECIAL THIS MONTH:
SAVE\$\$

CELESTRON 8

Special coatings, wedge, and tripod

CELESTRON 90

Astro telescope with Celestron wedge
and solar filter.

CELESTRON 90

C90 on Meade equatorial mount, 18mm
ocular, Barlow lens, diagonal. **\$385**

μTRAC™.M.

Available Soon — A New
Standard in Drive Correctors

Free shipping in Continental U.S.A. California
residents please add sales tax.

96 pages of catalogs and manuals—\$2, refund-
able with first order. Free price list on request.

Demonstrations by appointment, or call to dis-
cuss your specific needs.



EUGENE L. CISNEROS
OPTRON SYSTEMS

704 Charcot San Jose, CA 95131
Phone: (408) 263-5422 Days
923-6800 Evenings

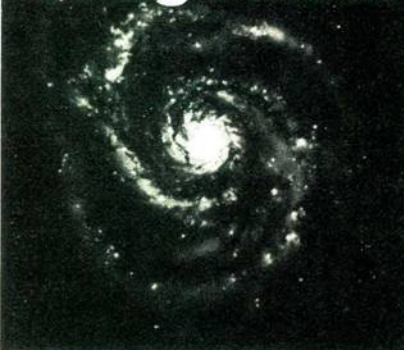
FOR SALE — 4-1/4" reflector, 3 eyepieces, accessory
case, 7 coated lenses, solar and lunar filters,
equatorial mount; \$250.00. "The Illustrated
Encyclopedia of Astronomy and Space;" \$5.00. Both
new; you pay shipping. Contact Mark Alsing, 318 N.
Center, Plano, IL 60545. Phone (312) 552-3708.

FOR SALE — ASTRONOMY magazines: August and
September 1973; January, March, April, and
September through December 1974; 1975 through
1978 complete. Excellent condition; entire lot \$50.00
plus postage. Write J.F. Atchison, 630 S.W. 6th Street,
S.G. Villa 58, Pompano Beach, FL 33060.

FOR SALE — 6" Alvan Clark refractor. A 19th century
instrument; good condition, excellent optics. Contact
Timothy Barker, Wheaton College, Norton, MA 02766.
Phone (617) 285-7722, ext. 422.

FOR SALE — Back issues of ASTRONOMY: November
1974; January 1975 through August 1979. All issues
mint condition. Price: \$60.00 postpaid, firm. No single
copies. Contact Earl J. Beck, R-5, Box 36, Kingston,
TN 37763. Phone (615) 376-6260.

The Next Best Thing To Being There!



FULL-COLOR POSTERS SLIDES • POSTCARDS PRINTS • MAPS • CHARTS

A single source for space visuals from

HALE OBSERVATORIES
LICK OBSERVATORY
U.S. NAVAL OBSERVATORY
NASA, AND MORE!

The highest quality, the lowest prices
Posters — \$2.00 Slides — 40c
40% discount on orders over \$25.

Write Dept. A for free postcard
and our new illustrated catalog.

Hansen Planetarium

15 South State Street
Salt Lake City, Utah 84111



B.E. MEYERS & CO.
Precision Optical Systems & Components
Varo Night Vision & Image Intensifier Systems
Industrial Machine Tools
Ultra-High Intensity Portable & Marine Lighting

GIANT PRE-CHRISTMAS SALE

Special New Product Series!

B.E. Meyers & Co. are pleased to announce our appointment as National Service Distributors and Original Equipment Manufacturers for Varo Night Vision Systems & Image Intensifiers.

We can now offer the finest complete line of 1st and 2nd generation 18mm to 100mm intensifiers and power supplies in housings built especially for your instrument, be it 8" or 200"

From \$1,000.00 up



Our engineer John Patrick designed this super lightweight portable tripod and wedge. The unit is manufactured from rigid honeycomb aluminum and very strong. Weight is an amazing 3 lb. 7 oz. complete \$169.95



New
1,000,000 candlepower hand held Kenon search light. Brighter than the landing lights of a "747" aircraft. Weight 7.1 lbs. Rechargeable Light only — \$475.00



Noctron IV

Weight 3.8 LB.

Special Introductory Sale!
\$2,595.00

Typical Amplification 80,000x

All adapters to mount on C-14 or other 2" included free. Call or write for more info.



New

35,000 candlepower 16 1/2" Quartz-Halogen rechargeable flashlight.

\$122.00

Lowest prices on Celestron — Meade or Edmund — we guarantee it. In stock too!

DewCap C-8 —

19.95

RFC —

69.95

C-8 Lat. Adj.

24.95

C-14 Lat. Adj.

59.95

Solar Filter

5.00 yd.

B.E. Meyers & Co.
2717 200th Ave. S.E.

Issaquah, Wash. 98027 Telephone (206) 392-2237

As always — satisfaction guaranteed or money refunded.

We honor Master Charge and VISA.

FOR SALE — ASTRONOMY back issues: October 1975; July 1976 through October 1979 (missing October 1976); plus 1976 through 1978 indexes. Excellent condition; sell as set only. Best offer. Contact Robert Dodell, 5201 N. 44th St., Villa 27, Phoenix, AZ 85018. Phone (602) 959-3502.

FOR SALE — Dynamax 8, tripod, variable drive, 8x50 finder, counter weights, Barlow, 12.7mm, 18mm, 30mm, 50mm lens, poro prism and accessories. Price: \$600.00 or best offer. Contact S. Ganderson M.D., 249 Allegheny Ave., Hanover, PA 17331. Phone (717) 637-7000.

FOR SALE — Kenton Electronics model 7500 quartz drive corrector, 10 watts maximum, including 110 AC to 12 DC home supply and two 30 foot field cables; \$150.00. Also standard Celestron telecompressor (f/5); \$25.00. Write Martin Germano, Box 3605, Thousand Oaks, CA 91359.

FOR SALE — Questar standard 3-1/2" telescope with Gitzo tripod, power guide, piggyback mount, Brandon eyepieces (8mm, 12mm, 32mm), 1-1/2" Barlow lens, sun filter, camera coupler. New, worth \$2,500.00. Questar says sell \$2,000.00. Selling \$1,500.00, excellent condition. Call D. Goldman M.D., (717) 392-0423 evenings.

FOR SALE — Several purpose instrument from Robert Little. Includes 135mm Soligor f/1.8 telephoto, diagonal, camera adaptors, brackets, lenshood, case. Mint condition. With your eyepiece, 75mm finder or RFT. Piggyback astrophotography. Price: \$100.00 firm. Contact David Healy, 55 Lake Road, Manhasset, NY 11030.

FOR SALE — 6" Dynascope, clock drive, 8x50 finder, eyepieces (9mm, 18mm), 8.4-21mm zoom orthoscopic, 2.5x Barlow plus end rings and dust caps. Price: \$300.00, negotiable. Contact Steve Johnson, 2121 Kendall Ave., Madison, WI 53705. Phone (608) 233-5924.

FOR SALE — 1 pair Edmund 2" I.D. finder ring mounts with hardware; \$5.00. Also Sky and Telescope magazines: February 1973 to January 1975 in very good condition. Call or write Lee Keith, 3355 N. Oakland, Apt. 302, Milwaukee, WI 53211. Phone (414) 964-6638 evenings.

GLOBES FROM ASTRONOMY

Beautiful additions to your home, office, classroom or library. Accurate and sturdy, they are made by Replogle, the world's largest manufacturer of fine globes.

The Apollo

12" celestial globe shows 1,200 stars to 4th mag. Includes clusters, novae, doubles and the Milky Way! Gyromatic mounting in silver finish, complete with illustrated booklet.

16 1/2" high \$19.95



NASA Moon Globe

Official 12" globe with NASA-approved detail! Extremely accurate, it is strikingly 3-dimensional, rests on a molded base and comes complete with booklet and study projects.

\$17.95 15" high



The Lenox

Beautiful 12" raised relief globe with parchment effects, cartouches and compass roses giving an elegance and charm to any room. Antiqued fruitwood finish on base and half meridian ring.

18" high \$29.95



To order use form bound into this magazine.

PUT STARS IN THE EYES OF SOMEONE YOU LOVE THIS HOLIDAY SEASON

CHECK OUR IDEA LIST for all of those special items you would like to give or receive. We have them all!

SHOPPING LIST:

- ☐ **C8, C5, C90** — Compare and Save \$.
- ☐ **C-NOBS** for C5 & C8, Nine knobs for \$15.00.
- ☐ **DRIVE CORRECTORS:**
 - 12 V DC only \$ 57.00
 - 12 V DC/110 V AC \$117.00
 - Dual-axis w/dec. motor & joystick \$190.00
- ☐ **EYEPIECES:**
 - Highest Quality Ortho, 4, 7, 10.5, 16.8, 28mm \$37.00 ea.
 - Highest Qual. Erfle, 12.4, 15.5, 20mm \$42.25 ea.
 - Best Buy Ortho, 4, 6, 12.5, 18, 25mm \$26.50 ea.
- ☐ **NEBULAR FILTERS** — Celestron & Daystar from \$69.95.
- ☐ **EYEPIECE FILTERS** — Wratten type & polarizers . . . \$7.50 ea.
- ☐ **ASTROPHOTOGRAPHY ACCESSORIES** — All Celestron factory-standard accessories.

And there's MORE IN OUR CATALOGUE! See us to see it your way . . .

COLE ENERGY SYSTEMS

P.O. Box 1214-A • Maitland, FL 32751
(305) 831-3809

FOR SALE — ASTRONOMY back issues: January 1975 to present, complete. Excellent condition; \$150.00. Contact John Berry, 1520 Aberdeen Ave., Baton Rouge, LA 70808. Phone (504) 344-8760.

FOR SALE — Celestron telescope; Minolta 800mm F8 telephoto; Swift binoculars; Polaroid ED-10 camera; Celestron telephoto; Konica T3 SLR; Craig calculator; Celestron guidescope. Some equipment never used. Cash and carry only. Contact Dan Carman, 4209 Edgmont Ave., Brookhaven, PA 19015. Phone (215) 876-1544.

FOR SALE — Celestron 5, special coatings, mini-tripod, 3 oculars, Barlow, T-adaptor and more. Price: \$650.00. Contact Allen Cziok, 11610 37th Pl. North, Plymouth, MN 55441. Phone (612) 559-3618.

FOR SALE — Searchlight fork mount; ideal for large telescope. 29" wide between fork, 24" deep from altitude bearing axis. Price: \$250.00 or best offer. Write Diane Lucas, 39615 Carol Ln., Elyria, OH 44035.

FOR SALE — Sears 2.4" equatorial refractor with 22mm ocular, Barlow, erecting prism, star diagonal, sun and moon filters, finderscope, carrying case. Good condition; \$100.00 plus shipping. Contact Steven Wyrick, R.R. 2, Box 169, Andersonville, TN 37705. Phone (615) 992-0204.

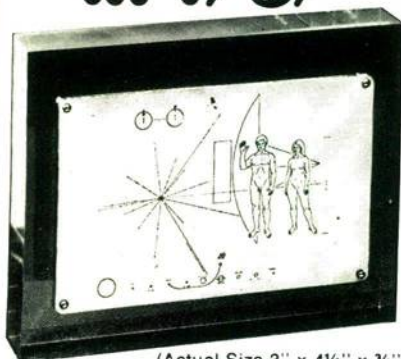
FOR SALE — Criterion Dynamax 8, field tripod, drive corrector, 5 eyepieces, off-axis guider, adaptors, illuminated reticle eyepiece, more. Price: \$1,100.00. Call or write Don Jones, 2579 Dering Ct., Atlanta, GA 30345. Phone (404) 636-4540.

FOR SALE — Back issues of ASTRONOMY: March 1974 through September 1979. Top condition; \$125.00 prepaid. Contact Jack Kahoun, 924 Viewridge Dr., San Mateo, CA 94403. Phone (415) 349-4696.

FOR SALE — Criterion RV-6" telescope with mount, motor drive, Barlow, 5 oculars including Erfle and orthoscopic, plus filters. Price: \$225.00. Contact Jack Kahoun, 924 Viewridge Dr., San Mateo, CA 94403. Phone (415) 349-4696.

FOR SALE — Cave Optical 10" f/6 Newtonian reflector. Perfect condition; \$750.00. Write J. McDonald, 213 Wildwood Rd., Council Bluffs, IA 51501.

in 1987



(Actual Size 3" x 4 1/4" x 3/4")

Pioneer X will pass Pluto's orbit and leave the solar system. In case the capsule is intercepted by extraterrestrial beings, there is a plaque carrying an ingeniously designed coded message indicating its origin.

This plaque has been reproduced in solid brass with the message engraved on one side, the decoding engraved on the opposite side.

The plaque is also available in a solid brass buckle & T Shirts. Please specify size.

"T" Shirt	\$ 6.50
Belt Buckle	\$14.92
Buckle with antique brown belt	\$21.92
Brass & Plexiglass Plaque	\$24.92

New Jersey residents add 5% sales tax.

C&G
enterprises

PO Box D, Dept. C
Alpha, N.J. 08865

CANADIANS

ASTRO TECHNICS offers:

- CELESTRON telescopes from stock at tremendous savings
- OPTICAL TECHNIQUES equipment... including Quantum 4 & Quantum 6
- ASTRO-PHYSICS drive correctors, trackers, eyepieces and more

Most items delivered via
FIRST CLASS, REGISTERED
MAIL.

Call or write for FREE price
lists. Or send \$2.00 for a
complete catalog package.

ASTRO TECHNICS LTD.

2984 Kitchener St., Vancouver, B.C. V5K 3E5 Phone: (604) 255-7211

CELESTRON BUYER:

Don't get your axis system off guidance — for most competitive prices on the Celestron line, contact us. \$1.00 brings catalogue and \$10.00 credit coupon.

VISA & Master Charge Financing.

Model Haven

P.O. Box 101, Fork, Md. 21051

PH (301) 879-3451

AUTHORS WANTED BY NEW YORK PUBLISHER

Leading book publisher seeks manuscripts of all types: fiction, non-fiction, poetry, scholarly and juvenile works, etc. New authors welcomed. For complete information, send for free booklet W-79. Vantage Press, 616 W. 34 St., New York 10001

FOR SALE — New dealer cuts prices

on Mayflower, Unitron, other telescopes and equipment. Reflectors and refractors available. Binoculars, microscopes, weather instruments too. For details, send 50¢ and SASE to Elliott Hume, 63 Linwood, Warsaw, NY 14569. Ask for List "B".

KALAMAZOO OR TIMBUKTU

To anywhere on Planet Earth your post-paid order's on its way within a day. To reach you intact, all books are plastic wrapped and packed snugly in stout cartons. Without delay, summon your free copy of our book list for astronomers today.

VINTAGE BOOK COMPANY
Box 16182, Elway Station
Saint Paul, Minnesota 55116 USA
612-690-2363

CELESTRON TELESCOPES ON DISPLAY AND IN STOCK

E & W OPTICAL, INC.
2420 EAST HENNEPIN AVE.
DEPT. AM
MINNEAPOLIS, MINN. 55413
612-331-1187

SEND FOR PRICE LIST "A"—
Astronomy supplies and accessories

MOBILE TELESCOPE SALES

We demonstrate by appointment
Popular sizes with low prices
Most Indiana (317) 883-5692
evenings

Old, Rare,
Out of Print

- MOON
- STAR ATLASES
- ASTRONOMY BOOKS
- PRINTS

Works by Cassini, Fauth, Herschel, Neison, etc.
To receive our illustrated catalogues, send \$2.00 to:

G.B. Manasek
P.O. Box 909, Chesterton IN 46304

"Priceless..."

Your Astronomy courses are excellent. Never have I undertaken any educational course where the school was more interested in actually wanting its students to LEARN what was taught, rather than issue a passing grade. What I have learned is priceless. Many thanks.
Jack D. Ellis, Oklahoma City, Oklahoma

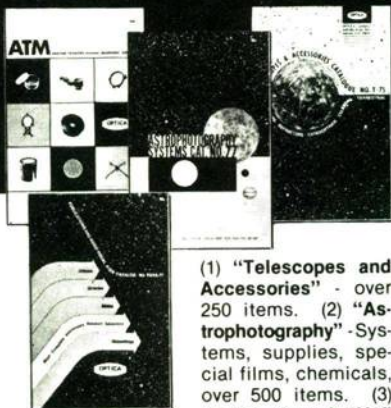
Coast Navigation School specializes in individual instruction. Call or write today for our free course catalog describing our streamlined home study courses designed especially for amateur astronomers.

CELESTRON Schmidt-Cassegrain and UNITRON refractor telescopes available.
Special prices on course/telescope combinations.

Coast Navigation School of Astronomy
Dept. 5112 1934 Lincoln Drive
Annapolis, MD 21401 (301) 268-3120 37
I'm interested! Please send me your free school catalog.

Name _____ Address _____
City _____ State, Zip _____

4 OPTICA b/c CATALOGUES



- over 300 books, atlases, maps, slides, posters, recordings, globes, etc. (4) "ATM" - goods for the telescope maker, -over 400 items. Each catalog - 50¢; all four - \$1.50 for handling and postage. Send cash, check or U.S. stamps. Also receive **FREE** current Astronomical Events Calendar, a wealth of useful information. **FOREIGN** - Each catalogue \$1.00; all four \$3.00. Must be paid by an International Postal Money Order or a check drawn in U.S. Dollars on any bank in the U.S.A. For Airmail, add \$2.00.



OPTICA b/c Company
SALES/SERVICE DIVISION

4100 MacArthur Blvd., Oakland, Calif. 94619

47st. photo

YOUR ONE STOP SHOP FOR QUALITY AND LOW PRICES

New York's greatest source of photography equipment -- is now your source for all your Astronomical needs - Full line of Celestron telescopes, binoculars, tele-lenses, LPR filters.

Lowest prices on Celestron 5 and 8 special coating, wedge and tripod, Celestron 90 - oculars, wedge, tripod, barlow lens.

Capture the moon and beyond with a Celestron and camera combination with our low low prices.

Call Toll Free 800-221-5858 or 800-223-5661. In New York, Alaska and Hawaii, call (212) 260-4410.



Discount Catalog with this ad.

47th St. Photo, Inc.
67 West 47th St.
New York, N.Y. 10036 212-260-4410

FOR SALE — 3-1/2" standard Questar with CerVit mirror, wide field, broad band and low reflective coatings, all Questar accessories. All like new. New, \$2,500.00; price, \$1,850.00. Contact Henry M. Lindsey III, 626 W. 15th St., Laurel, MS 39440. Phone (601) 649-1678.

FOR SALE — Astroscan 2001 5 months old. Like new including aluminum stand, tripod bracket, dust cover, carrying straps, 2 eyepieces (28mm and 8mm), eyeguard and tote bag. Price: \$170.00. Contact Tim Malby, 7 Maple Ave., Montvale, NJ 07645. Phone (201) 391-4544.

FOR SALE — Sky and Telescope magazines: August 1965 to October 1968. Also Review of Popular Astronomy: June 1965 to April 1969. Total of 55 issues; \$35.00 for all, plus postage. Write S. Mesics, 276 Thunder Circle, Bensalem, PA 19020.

FOR SALE — Coulter 2.14" M.A. elliptical secondary, \$10.00; 6" f/8 Meade primary, \$25.00; Novak secondary holder 2.14" M.A. and spider for 7"-8-1/4" tubing, \$10.00. Contact Steve Metz, 4626 Verona Ave., Jacksonville, FL 32210. Phone (904) 388-6074.

FOR SALE — ASTRONOMY back issues: January 1976 through September 1979. All issues excellent condition; \$70.00 firm. You pay shipping. Contact Steven Pries, W263 S7480 Mt. Everest Rd., Waukesha, WI 53186.

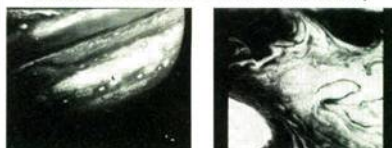
FOR SALE — Issues of ASTRONOMY: August 1973 through August 1979. All issues mint condition. Will ship in U.S.A.; \$175.00. If you miss this bargain your check will be destroyed. Contact Roger Snowdall, 8405 Everett, Raytown, MO 64138. Phone (816) 356-0396.

FOR SALE — Meade 8" reflector f/6, model 826, with motor drive. Hardly used; \$300.00. Contact Marc Triolo, 118 E. Prospect Ave., State College, PA 16801. Phone (814) 237-1547.

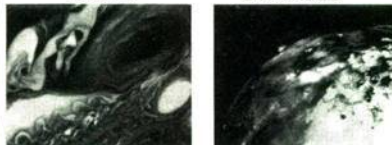
FOR SALE — Celestron 8 with wedge, tripod, 4 oculars, eyepiece filter set, right angle finder, Nikon T adaptor, drive corrector, custom anvil flight case and accessory cases. Price: \$1,200.00, you pay freight. Contact P. Upchurch, 23222 Via Barra, Valencia, CA 91355. Phone (805) 254-1025.



BRINGING THE HIGH FRONTIER TO YOU
Satisfaction Guaranteed—Allow 3 Weeks Delivery



(A) JUPITER WITH IO & EUROPA (C) JUPITER—BLUE ENHANCED



(B) WAKE OF GREAT RED SPOT (D) ERUPTING VOLCANO ON IO

Finest Quality — Full Color Lithographs from NASA—JPL Photos Retrieved During Mission With Official Photo Caption. Each Measuring 18" x 24" Ready For Framing.

SEND—\$8.95 Each 1 Image; \$6.95 Each 2 or More Images— Plus \$1.50 Handling USA \$2.50 Foreign

TO: VOYAGER IMAGE

6887 Yeager Place
Los Angeles, CA 90068

Selection:

A B C D

Quantity:

A B C D

NAME _____

ADDRESS _____

CITY _____ STATE _____ ZIP _____

POTTER SALES & SERVICE

Celestron . UNITRON . MEADE

VERNONscope . UNIVERSITY OPTICS .

DayStar Filters, DOAA, ASTROPHYSICS,
CROSS OPTICS

Demonstrations by appointment

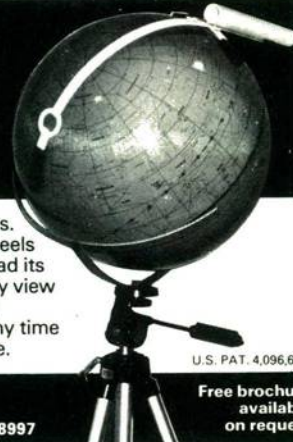
723 CEDAR, DEPT. AM,
SANDWICH, IL 60548
815-786-8168



FOR YOUR ASTRONOMICAL NEEDS

STARLOC ★ NEW INVENTION: LOCATE/IDENTIFY STARS

Sets up in one minute—adjusted for use in two minutes. Far easier to use and more accurate than starfinder wheels and star charts. Simply sight a star and immediately read its name or set the locator on a star name and immediately view that star through a sighting tube. This newly patented invention works anywhere in the world, any season, any time of night without adjustments for date, hours or latitude.



U.S. PAT. 4,096,646

Send \$49.95 plus \$1.75 postage and handling to:

STARLOC — A, 30 West Arrowhead Road
Duluth, Minn. 55803 (218) 724-8997

Free brochure
available
on request

FOR SALE — 7mm, 16.8mm, 28mm Meade research
orthos; 8.4-21mm ortho zoom; 2" 60mm Kellner;
Unihex, duetron; \$25.00 each. Wide star diagonal,
Amici prism, mirror diagonal; \$15.00 each. WANTED
— 14" F5 Newtonian less mount. Contact Ken
Zmijewski, 2121 Woodford, Vienna, VA 22180. Phone
(703) 790-9572.

color SPACE photos

bring
outer
space
into
your
home
or
office



• JUPITER* • EARTH RISE* • FULL EARTH*
• MARTIAN SUNSET* • THE GREAT RED SPOT*

**3"x2" Full Color Reproductions from Official
NASA Color Photos Ideal for Home, School or Office**

NASA'S Most Beautiful scenes from space are now available as large, titled, **Full-Color Prints**. Taken from deep space these beautiful color photos reveal for the first time in history the grandeur of outer space and its celestial splendor. For greatest clarity and fidelity they are reproduced by the highest quality, full color lithography on heavy Kromekote paper. Available unframed, or quality framed with color coordinated mat, contemporary silver chrome frame, and non-glare glass.

FRAMED	UNFRAMED
*36" x 24" *24" x 18"	*34"x22" or *21"x16"
\$6495	\$1695 each
Plus	
\$5.05 Insurance/Postage	\$3.05 Insurance/Postage

"Fantastic!" "Tremendous Pictures!" "Incredibly Beautiful!" are a few of the superlatives expressed about these reproductions.

**ORDER NOW
TOLL FREE!**

**1-800-824-7888,
Op. #462
in Calif. 1-800-852-7777,
Op. #462**

**FREE
Catalog
Full-color**



Woodstock Products

**P.O. Box 4087 Dept. A-14, Beverly Hills, California 90213
"BRINGING OUTER SPACE DOWN TO EARTH"**



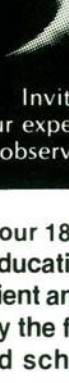
TEXAS NAUTICAL

REPAIR CO.

We should be the last place you call! Tell us what price you've been quoted by any other dealer on a Celestron, Meade, Unitoron, or Edmund telescope, and we will go light-years out of our way to beat or match it. Even if we can't, you will have found out yourself that we are the dealer that really cares! We won't try to sell you something that you don't need or want, and we don't deal in "Gimmicks". We sell service, at honest prices!

We also carry accessories by Meade, Gieseler, Edmund, Clave, and others. Call us for your astronomical needs.

3209 Milam, Houston, Texas 77006
(713) 529-3551

[illegible]

SOLAR ECLIPSE

February 16, 1980

Invitation to join any of
four expeditions to India & Nepal
to observe the total solar eclipse.

**Four 18-day itineraries. With
educational programs on Ancient
and Modern Astronomy
by the following distinguished
scholars:**

Alan Friedman, Director of Astronomy
and Physics at the Lawrence Hall of
Science, University of California,
Berkeley.

Lee Simon, Director of the Morrison
Planetarium at the California Academy
of Sciences, San Francisco.

Cary Sneider, Assistant Director of
Astronomy and Physics at
the Lawrence Hall of Science, University
of California, Berkeley.

Martin Cohen, Senior Post-Doctoral
Associate, NASA/AMES Research
Center, Mountain View, California.

Each expedition visits London,
Bombay Agra, Jaipur, Calcutta,
Kathmandu, Delhi, with in-
teresting and comprehensive
sightseeing, visits to obser-
vatories, meeting with local
astronomical societies.

Price is \$2145.00, including
\$50.00 educational fee. This
price is based on lowest possi-
ble air fare from New York and
return.

Arrangements include deluxe
hotels and all meals in
India and Nepal. First Class
hotel with breakfast in London.

Call or write for brochure with
complete details. Book early to
take advantage of this unique op-
portunity for an interesting travel
program, a view of the total eclipse,
and a fascinating educational pro-
gram presented by foremost ex-
perts in astronomy.



prime tours inc.

Travel arrangements by:

Schoonmaker Point Building
Sausalito, California 94965
Telephone (415) 332-5791

in cooperation with:

AIR-INDIA



The Expanding Search

Today the boundaries between science and religion are rapidly vanishing. Could it be, as many scientists are now concluding, that there exists an underlying unity? Are the answers sought by each to be found through an expansion of consciousness wherein truth is clearly perceived?

Paramahansa Yogananda, founder of Self-Realization Fellowship, said, "Truth is no theory, no speculative system of philosophy, no intellectual insight. Truth is exact correspondence with reality. For man, truth is unshakable knowledge of his real nature, his self as soul."

For more than half a century, Self-Realization Fellowship has been teaching scientific techniques of meditation and life-energy control that you can test in the laboratory of your own life. Through the experience of meditation you can transform abstract truths into a living reality. As you begin to know and express your real nature, you discover the infinite source of all life within you. Then you won't need to speculate about the meaning of your existence; you will know.

SEND FOR FREE BOOKLET



Self-Realization Fellowship

3880 San Rafael Ave., Dept. 9A SJ
Los Angeles, California 90065

Please send me a free copy of your booklet "Undreamed-of Possibilities."

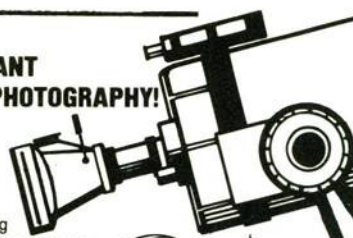
NAME _____
STREET _____
CITY _____
STATE _____ ZIP _____

READ "Autobiography of a Yogi"

The fascinating life story of
Paramahansa Yogananda
AT BOOKSTORES EVERYWHERE

INSTANT ASTROPHOTOGRAPHY!

For beginning astrophotographers and educators — cameras accept Polaroid® film packs for instant celestial photography.



SKY SCIENTIFIC
28561 Highway 18
P.O. Box 184
Sky Forest, CA 92385

Tel: (714) 337-3440

For advanced amateurs and professionals — our cameras also accept conventional sheet films. Prices start at only \$75. Off-axis guider models from \$105. Free brochure and photo

Authorized dealer for CELESTRON and MEADE.

CANADA'S LARGEST SOURCE FOR QUALITY TELESCOPES



EFSTONSCIENCE INC.

3500 BATHURST ST. TORONTO, M6A 2C6

ALL NEW DESIGN TELESCOPES & ACCESSORIES

EDMUND SCIENTIFIC PRODUCTS

AVAILABLE FROM STOCK AND ON DISPLAY

AS CANADIAN DEALERS FOR

CELESTRON® PRODUCTS

We offer the new LPR Filter at 20% disc. with the purchase of any telescope.

SEND \$1.00 FOR A NEW 200 PAGE EXCITING CATALOGUE

FOR SALE — C-8 finderscope, standard 6x30. Mint condition; \$20.00. Contact Paul D. Webb, Rt. 5, Box 485 26-A, Shelby, NC 28150. Phone (704) 482-4824.

FOR SALE — 66 issues of B.A.A. Journal, 1968-1978; 66 issues of Strolling Astronomer Magazine (A.L.P.O.), 1968-1978. Price: \$40.00 each set or both for \$75.00, plus shipping. Write Robert A. Yajko, 123 Summit St., RD #4, Leechburg, PA 15656.

FOR SALE OR TRADE — 6" f/8 reflector, Coulter optics, Edmund mount and clock drive, 2 eyepieces (optional), etc. Price: \$165.00 without eyepieces. Sorry, at this price you pay shipping. Contact Dave Kratz, 39 Briarwood Rd., Catonsville, MD 21228. Phone (301) 747-1852.

TRADE — 16-7/8" mirror blank rough ground f/4.5; 8" mirror (finished, not aluminized) f/8; 6" Optika f/8 Newtonian complete; 7 eyepieces, 16 filters, more. Send for list. WANTED — 12-1/2" Cave Newtonian. Contact Dennis Merrill, 6701 Taffy Ct., Pleasanton, CA 94566. Phone (415) 846-1247.

WANTED — Correspondence with persons (13-16) interested in astronomy. Write Corey Coppola, 117 Diana Rd., Plantsville, CT 06479.

WANTED — Plan to build backyard sliding roof observatory. Need ideas, plans, books, etc.; willing to compensate. Write Rick Garcia, 6427 Thoreau's Way, San Antonio, TX 78239.

WANTED — 6mm or 8mm Brandon Orthoscopic eyepiece, standard 1-1/4" diameter, must be in excellent condition. Will buy or have Brandon 24mm eyepiece to offer in trade (never used). Contact Frank Gregorio, 19 Dose Rd., Wappinger Falls, NY 12590. Phone (914) 297-2089.

WANTED — Correspondence with anyone (especially teenagers) who would like to discuss meteor showers, telescopic observations, current astronomy events, etc. Please write to Steve LaFlamme, 110 Stonybrook Rd., Raynham, MA 02767.

WANTED — Information on plans and/or schematics to convert shortwave C.W. radio to simple radio astronomy setup. Write Todd Moore, Rt. 4, Box 61, Ponca City, OK 74601.

WACKS

5722 W. North Ave.
Milwaukee WI 53208
414-442-3441

THE CENTER OF THE UNIVERSE

Immediate delivery from stock

• Celestron • Unitron • Edmund

You know what you're getting from Wacks — 30 years of the finest equipment, with service to match. We make no claims we can't fulfill, and we'll give you the same prompt attention that literally thousands of buyers have enjoyed.

Contact us for free quote or
send \$1 for catalog & price list



HEY IOWA
and plains states
There Is A Telescope Dealer In
Des Moines With The
Lowest Prices In The Country.
that we know of
FOR INFORMATION:
OMNI OPTIKS
6013 Crown Lane
Des Moines, IA 50311
Dealers for:
Celestron • Meade • Unitron
We also deal in Planetarium Supplies
and visual effects.

INDIVIDUAL EYEPIECES CAN NOW BE PROTECTED TO THE MAXIMUM!

Designed especially to prevent dust, moisture and optical breakage, these durable white plastic containers, with imprinted screw-lock lids utilize custom die-cut polyurethane foam insuring maximum protection and easy access to eyepiece.



3-CONTAINER SERIES:

#20 Series: Eyepiece height — 1.00" to 1.75"; state diameter — .917", .966", 1.25"; Price — \$1.50 each.
#30 Series: Eyepiece height — 1.75" to 2.75"; state diameter — .917", .966", 1.25"; Price — \$1.75 each.
#50 Series: Eyepiece height — 2.75" to 4.38"; state diameter — .917", .966", 1.25"; Price — \$1.95 each.
Postage paid — Send eyepiece dimensions.

EASTERN STATES DISTRIBUTORS

P.O. Box 124, Narberth, PA 19072 215-664-4610

WANTED — 6" f/6 or f/8 mirror and spider for same. Contact Lee Keith, 3355 N. Oakland, Apt. 302, Milwaukee, WI 53211. Phone (414) 964-6638.

WANTED — Correspondence with individuals seriously interested in astronomy. Also interested in playing 3-D chess by mail. Write (in Spanish or English) to Pedro Valdes, Baudelaire 910, Col. Obispado, Monterrey, N.L., MEXICO.

WANTED — Maksutov 8"-12" with or without mount. Quality instrument in excellent condition; any manufacturer. Will sell 4" Unitron objective complete with adj. cell and dew cap. Earlier optically superior model. Contact Lee Schur, 507 California Ave., Santa Monica, CA 90403. Phone (213) 393-8061.

WANTED — Telescope 4" or larger (prefer 6"). Send information and price to Lisa Wise, 132 Briarcliff Circle, Lynchburg, VA 24502. Phone (804) 237-2775.

INFORMATION WANTED — Concerning telescope buying or building. Have no experience, so any information no matter how trivial will be appreciated. Contact Dennis Joyce, 110 Bertram Pl., Syracuse, NY 13207. Phone (315) 476-5945.

ANNOUNCEMENT — High frontier information: Space Studies Institute, P.O. Box 82, Princeton, NJ 08540; and L-5 Society, 1620 N. Park Ave., Tucson, AZ 85719.

ANNOUNCEMENT — Applications available for 1980-82 Morehead Internship in Planetarium Administration and Education. Includes Master's Degree work, planetarium experience, tuition paid, stipend. Inquire: Morehead Planetarium, P.O. Box 1227, Chapel Hill, NC 27514. Deadline: February 15, 1980.

ANNOUNCEMENT — Call Seattle, (206) 324-ASTR.

ANNOUNCEMENT — NASA press releases and press kits. Voyager probes: 79-22, 79-23, 79-86. Pioneer Venus: 78-68, 78-101, 78-181, 79-13, 79-35. More. Write NASA Headquarters, Public Services LFF-3, Washington, DC 20546. Phone (202) 755-8370.

ANNOUNCEMENT — Willingboro Astronomical Society meets Fridays, 8:30 p.m., Willingboro Municipal Building, Salem Road, Willingboro, NJ. Call Philip A. Webber for directions and information. Phone (609) 871-7438.

SOLAR ECLIPSE 1980 GREETING CARDS

...AND COMMEMORATIVE ENVELOPES

This holiday season, send out cards announcing the great Afro-Indian Eclipse of 1980! Front of 5" x 7" ivory-white card has U.S. Naval Observatory chart of Feb. 16 event; inside of card has writing space; back of card has eclipse description/maps of East Africa and India. Matching envelope has flags of Kenya, Tanzania, and India with telescope and eclipsed sun. All printing is black on white enhanced with gray half-tone screens. **FEATURE:** cards and envelopes not sent beforehand can be brought on expeditions for do-it-yourself commemorative mailings on eclipse day.

Cards with envelopes 50¢ each (minimum order \$5.00, please) postpaid first class; 25 cards or more 40¢ each. Allow 7-14 days for delivery. N.Y. residents add 8% sales tax. Outside North America add 20% for air mail. **MONEYBACK GUARANTEE:** these cards are quality printed—return some or all within 10 days for refund if not delighted. **BONUS:** with orders of \$10.00 or more, receive our 77 postcard (Columbus Day Eclipse) and 79 postcard (Big Sky Eclipse) free. Phone: 212-866-0742

John R. Beattie Publishing Company
Grand Central Box 2138-AM1 New York, NY 10017

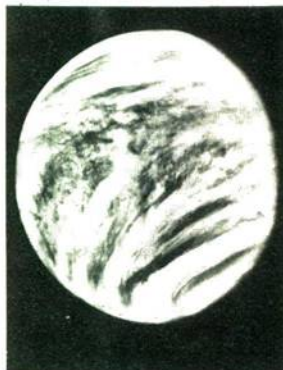
We Can Supply All Available Books On Astronomy

BURNHAM'S CELESTIAL HANDBOOK
Vol. 1, 2 and 3 each\$8.95 + \$1.00 postage
HISTORY OF THE TELESCOPE
by H.C. King, New Reprint\$8.95 + \$1.05 postage
NEW! SATURN AND BEYOND
by I. Asimov\$8.75
NEW! WEBB SOCIETY DEEP-SKY
OBSERVERS HANDBOOKS, Volume 1,
Double Stars\$7.50 + 75¢ postage
Volume 2, Planetary and Gaseous
Nebulae\$7.95 + 75¢ postage
NEW! DR. VEHRENBURG'S ATLAS OF DEEP-
SKY SPLENDORS. Rev. and enlarged edition\$37.50
ASTRONOMY: A HANDBOOK FOR
AMATEUR ASTRONOMERS, edited by
G.D. Roth\$17.95 paper, \$27.80 cloth
MATHEMATICAL ASTRONOMY FOR
AMATEURS by E.A. Beet\$8.95
AMATEUR TELESCOPE MAKING
Book 1 \$8.00, Book 2 \$9.00, Book 3 \$10.00
NORTON'S STAR ATLAS\$17.00

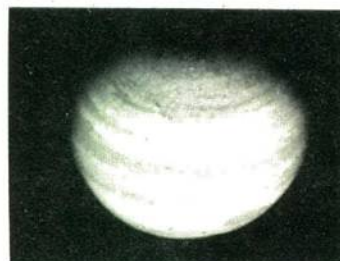
Write for NEW enlarged free list of astronomical literature

Herbert A. Luft
P.O. BOX 91, Oakland Gardens, N.Y. 11364

astro murals



C-7. Venus from Mariner 10



C-8. North Pole of Jupiter
from Pioneer 11

24" x 36" photo-quality prints of plates
from the world's great observatories.
Heavy matte paper. All postpaid.

The following are available:

BLACK AND WHITE

External Galaxies: #3. Triangulum; #4. Andromeda; #9. Canes Venatici; #14. Edge-on in Coma Berenices.

Galactic Nebulae: #2. Orion; #12. Trifid; #13. Horsehead.

Moon: #1. Third-quarter; #6. Southern section; #10. Full.

Sun and Planets: #5. Saturn; #7. Solar Prominences; #11. Corona.

COLOR

External Galaxies: C-5. Canes Venatici. **Galactic Nebulae:** C-3. Dumbbell; C-4. Lagoon; C-6. Eta Carinae.

Planets: C-7. Venus; C-8. North Pole of Jupiter.

Black-and-white Astro Murals —

\$7.50 each

Color Astro Murals — \$18.00 each

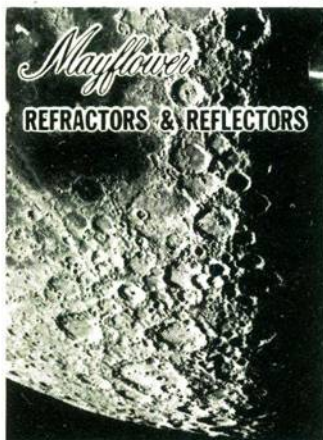
Set of 13 black-and-white Astro Murals

\$80.00

Set of 19 Astro Murals (13 b&w 6 color)

\$170.00

astro-murals Box 7563-A
703-280-5216 Washington, D.C. 20044



MAYFLOWER telescopes are engineered to utmost precision. Lenses and prisms are made of purest optical glass, ground to exacting tolerances. The achromatic objective is fully color corrected for distortion-free viewing. Optics are coated to increase light transmission, resulting in brighter, sharper image. Mechanical system is sturdy and well engineered giving smooth and flawless performance. Choose from a large selection of MAYFLOWER Refractors and Reflectors.

At leading stores everywhere.
Write for free brochure.



All Price
Ranges

Importers: COLONIAL OPTICAL COMPANY, INC. Phone: (213) 776-0777
8401 SOUTH LA CIENEGA BLVD. ★ INGLEWOOD, CALIF. 90301

I'D RATHER BE

IDENTIFY YOURSELF...

with our custom license plate frame.

The frames are triple-chrome plated, with white on blue lettering. Turn people onto Astronomy by letting them know your individual interests. \$3.95 ea., \$6.95 pr.

Satisfaction Guaranteed. Price includes postage & handling.

Send Check or Money Order to:

BOST PRODUCTS
12239 E. Shoreland Drive
Mequon, Wisconsin 53024

*Wisconsin Residents
Add 4% Sales Tax

STARGAZING

STAR DOME

NOVEMBER

by
Dewey Schwartzburg
and
James Mullaney

In many parts of the world, late autumn marks the beginning of a rainy season. The fair weather and steady winds so prized by sailors give way to months marked by storms, rough seas, and wet weather. The stars, important in numerous ways to sailors down through the centuries, have their part in announcing the onset of the dangerous wet season of the year.

We have seen in an earlier column how the rising of Capella and the "Kids" (in the constellation Auriga) was traditionally regarded by sailors as a warning of the coming months of poor weather. Indeed, the entire southern sky at this time of the year has a particularly "watery" aspect. Aquarius, the water carrier, pours out his urn of heavenly water into the mouth of the Southern Fish (Piscis Austrinus), marked by the brilliant star Fomalhaut (Arabic for "the fish's mouth"). The two fish of Pisces swim a

bit farther to the east, above the great bulk of Cetus the Whale, largest of all the constellations. Still farther east, the river Eridanus rises across the sky, while in the west Delphinus the dolphin leaps above the sea-goat Capricornus, who has the head and body of a goat but the tail of a fish.

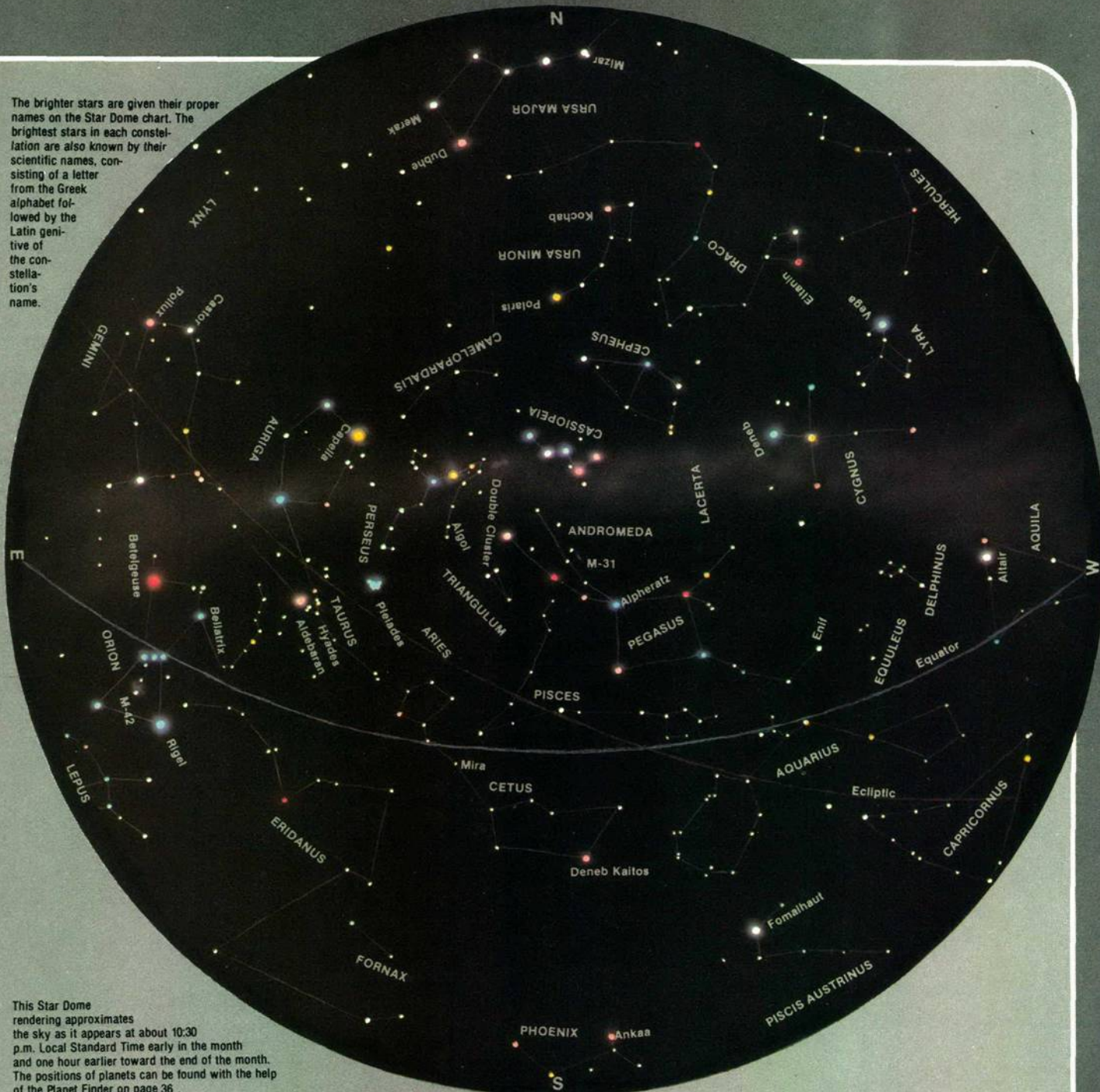
Farther up in the sky, the great beasts Taurus (the bull) and Pegasus (the winged horse) seem to be rising out of the waters below, and in fact these two constellations are often pictured as incomplete, their hind-quarters hidden below the waves.

It is almost as though the ancients saw the watery chaos thought to underlie Earth's foundations rising up into the southern sky at this time of year, threatening to overwhelm everything. Water, of course, has always been essential to life, but because of that fact it also holds a threat. Too little water results in a death-bringing drought, while too

much causes destroying floods. A common notion in ancient times held that the world was formed in the midst of an infinite watery chaos, and the Greek philosopher Thales even went on to theorize that everything was ultimately composed of water.

The wide-spread ancient myths of a cataclysmic Flood reflect the fear that the watery chaos surrounding the world might succeed in destroying it. Read carefully, the biblical account of the Flood makes it clear that the forty days of rain was no ordinary deluge from storm clouds: "The same day were all the fountains of the great deep broken up and the windows of heaven were opened." It must be remembered that in the first chapter of Genesis the "firmament," or dome of the sky, is established to separate "the waters which were under the firmament from the waters which were above the firmament." At the time of the flood, therefore, the firmament was breach-

The brighter stars are given their proper names on the Star Dome chart. The brightest stars in each constellation are also known by their scientific names, consisting of a letter from the Greek alphabet followed by the Latin genitive of the constellation's name.



This Star Dome rendering approximates the sky as it appears at about 10:30 p.m. Local Standard Time early in the month and one hour earlier toward the end of the month. The positions of planets can be found with the help of the Planet Finder on page 36.

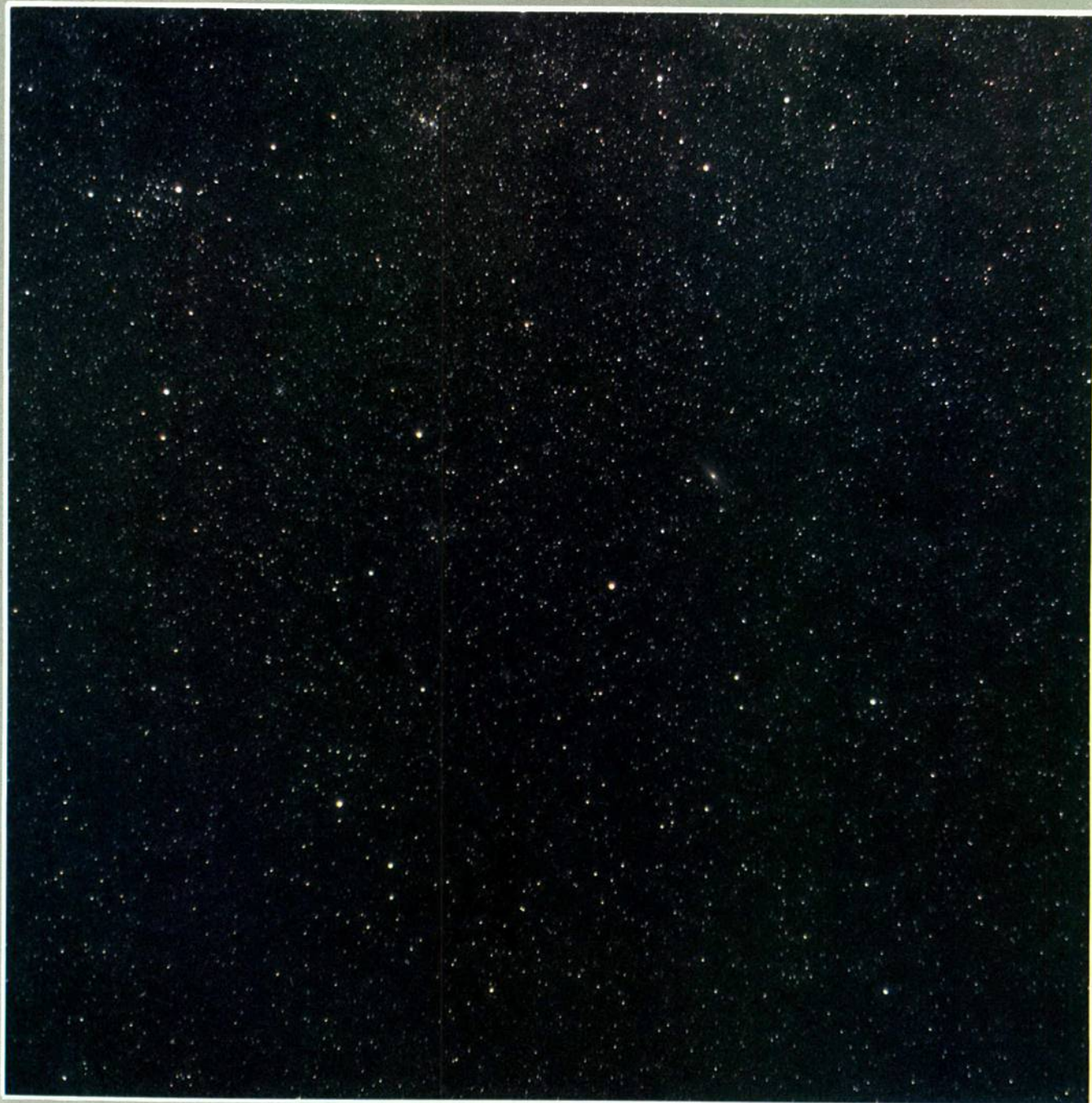
ed, allowing the cosmic chaos of waters above to pour down upon the Earth. This watery chaos, of course, completely surrounded the world, and so reference is also made to the "fountains of the great deep" being broken up, allowing the surrounding water also to well up from below.

The ancients, in ignorance of the natural processes taking place around them, lived in fear of a capricious, unpredictable world. The gods, of course, had power over the world and its processes, but they also were unpredictable and untrustworthy. One could never be quite sure, for example, that the god of the Sun might not one day neglect his (or her) duty and then the Sun wouldn't rise. Or

perhaps one year an unending winter would come with no spring. Sacrifices and prayers had to be made on a regular, seasonal and even daily basis to insure the proper operation of the cosmos.

It is against such a background that the divine promise made to Noah after the Flood takes on a powerful meaning: "While the earth remaineth, seedtime and harvest, and cold and heat, and summer and winter, and day and night shall not cease." The promise is an assurance that the orderly succession of the days and the seasons — the cosmic operation of the world — can be relied upon without fear. Unlike the other ancient Near Eastern cultures, the people of Israel could rely

on nature to function responsibly — natural disasters might still occur, of course, but they would not be wholly destructive of all creation. Freed from such cosmic concerns as whether or not the Sun would rise tomorrow or whether or not spring would return this year, the ancient Jewish religion was able to focus on ethical and behavioral concerns to a degree unmatched by any other contemporary religion. Of central importance were the doings of men and women here on Earth, not the operations of the heavens above. For the same reason, the widespread ancient superstition of astrology never found a comfortable place among the Jews, nor for that matter within their later offshoot of



Christianity.

We, of course, look up at the sky with the scientific world-view of the last few centuries — a view which it is important to remember evolved within the context of that same Judeo-Christian tradition. The well-known history of conflicts between Western religion and science often obscures a more basic connection. For us, as for the ancient Jews, the operations of the world and the motions of the sky above are natural, orderly, and dependable instead of capricious and mysterious — and therefore, we believe, ultimately comprehensible. The cosmic watery chaos “out there” no longer threatens us. As Shakespeare put it, “The fault, dear Brutus, lies not in our stars, but in ourselves.”

Close-Up

Andromeda

Arching above the waters below, borne up to safety by the winged horse Pegasus, Andromeda graces the heavenly vault high overhead on November evenings. With a sky “acreage” of some 700 square degrees, Andromeda ranks as the 19th largest constellation. Look for its prominent stellar arc formed by the stars Alpha (α), Beta (β), and Gamma (γ) Andromedae extending northeast from the Great Square of Pegasus.

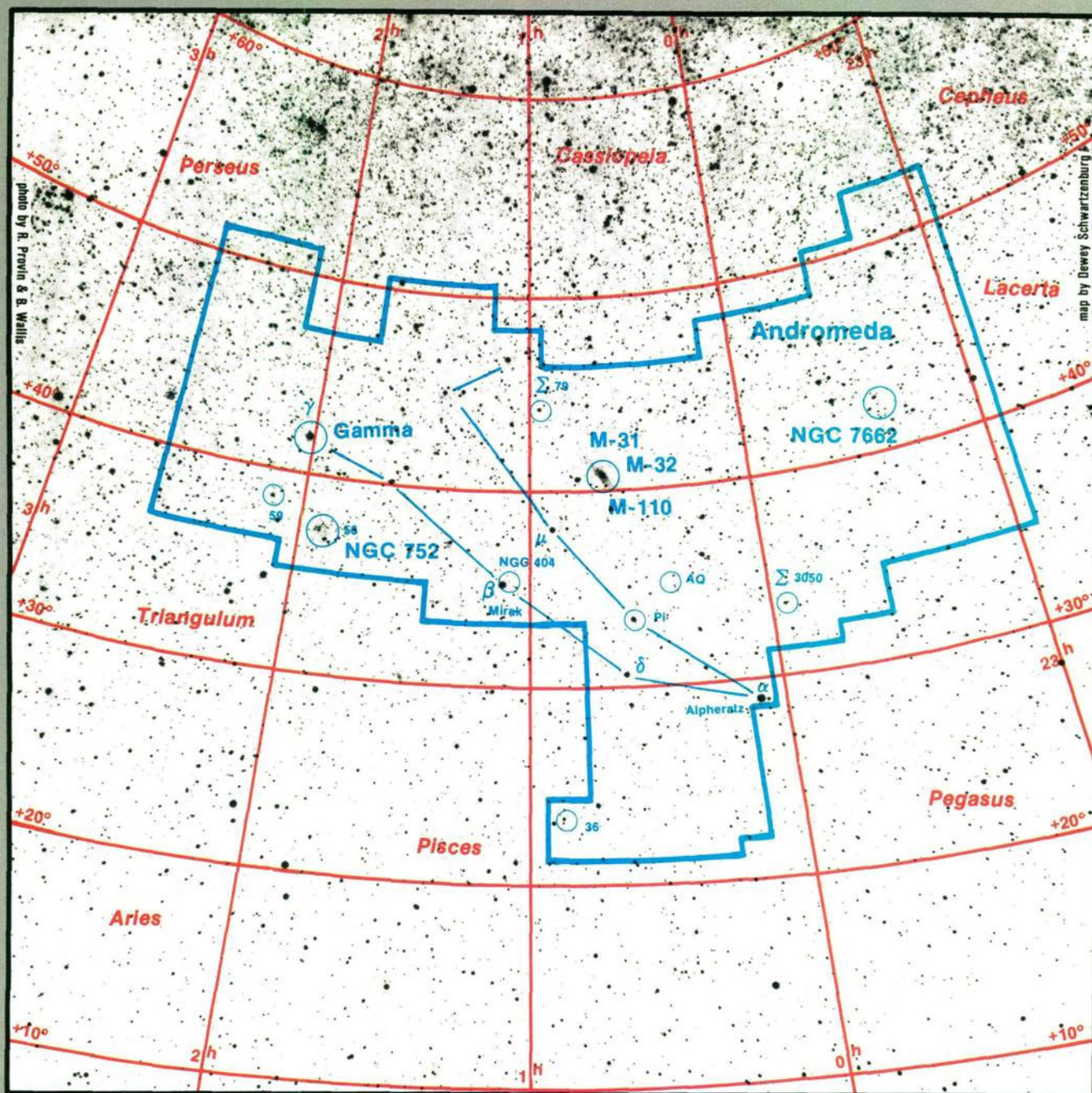
The daughter of Cepheus and Cassiopeia, whose stellar forms swing above the pole farther to the north,

Andromeda is tied together in legend with nearby Perseus as well (the full tale is recounted in *Star Dome*, November 1976).

Webb long ago remarked that “this constellation is rich in interesting objects of every class” for the observer with a small telescope — a fact you’ll discover for yourself in viewing the following sampling of its wonders.

Gamma (γ) Andromedae

Andromeda is noted for both a superb trio of galaxies (M-31, M-32 and M-110, see below) and a stunning trio of colorful suns, the triple star Gamma (γ) Andromedae. Discovered first as a double in 1788, its A and B components form one of the finest and brightest pairs in the entire sky for



telescopes of all sizes and types.

Gamma is at the end of an arc which begins with Alpha (α) Andromedae at the top left (northeast) corner of the Great Square of Pegasus. The A and B stars are of 2nd and 5th magnitude, respectively, and are separated by 10 seconds of arc near position angle 65°. Their contrasting colors are vivid in even the smallest glass — most observers see them as yellowish-orange and blue-green in hue. A 2.4-inch refractor at 75 power gives a thrilling view of this lovely duo and it becomes ever more spectacular with each increase in aperture.

Webb called Gamma "one of the most beautiful pairs in the heavens" and Smyth saw their tints as "deep yellow and sea green." Barns found

this object displaying "gorgeous coloring — burnished gold and cerulean blue" in his 10-inch reflector. Calling this a "superb object" and a "beautiful double star," Robert Burnham, Jr. noted that the "color contrast is unusually fine" and described the components as "golden yellow or slightly orange" and a "definite greenish-blue."

In 1842 the great double star observer Otto Struve found that the B component of Gamma Andromedae is itself a very close binary system having an orbital period of about 60 years. The B-C pair consists of 5.5 magnitude blue and 6.3 magnitude green suns whose current separation is just over 0.5 second in position angle 110°. Both stars are late B-type suns

(in striking contrast to the K2 primary) and will be at their widest separation of 0.6 second in 1982.

Pointing out that the close pair "forms an admirable test object," Webb cautioned observers that "it is important to note the difference between one long disk crossed by a dark interference line, which is sometimes called division, and two round disks with black sky between them." Good advice, for this object often appears elongated when viewed in small apertures.

The B and C pair of Struve is notoriously difficult to resolve, requiring a trained eye, excellent optics, and better than average seeing conditions (image steadiness). Considered a test for a good 8-inch, it is often

difficult even in a 12-inch at high power. Yet the stars have been split in apertures as small as 4 and 5-inches at magnifications of 400 to 500 times under superb seeing. Can you meet the cosmic challenge offered by this tightly bound duo in your telescope on a steady night?

Gamma Andromedae is actually a quadruple system, for the B member is an unresolved spectroscopic binary having a period of 2.7 days. All four stars appear as one to the unaided eye, and lie 260 light-years from us.

NGC-752

Moving further into space (to a distance of 1300 light-years), our next attraction is a large scattered open cluster of fairly bright stars known as NGC-752. Look for it in your finder some 5° south and slightly west of Gamma Andromedae, nearly touching the wide binocular pair 56 Andromedae (see table). Glowing with the combined light of a 7th magnitude star, its nearly four-score members are spread over an area 45 minutes across. This is appreciably greater than the apparent size of the full moon, making this clan easy to pass over in a telescope.

A 3-inch glass at 45 power shows the 56 Andromedae duo at the southwest edge of a large cloud of glittering stardust on a dark night, while a 6-inch scope at 50 diameters reveals a surprising number of additional apparent doubles within the cluster itself. Webb described NGC-752 as a "wide, rich region, especially of small stars" in his 3.7-inch refractor. Noting "curious groupings" here, Barns strangely logged this cluster as a

"nebulous unit" in his work.

Burnham considered NGC-752 "not spectacular visually," adding "the group is actually more conspicuous in good binoculars than in the average telescope, due to its large area and low density; it makes its best impression in relatively small rich-field instruments with wide-angle eyepieces." From your own observations, in which of the three types of instruments Burnham mentions do you find this stellar commune most attractive?

NGC-7662

Leaving behind the last swarm of stellar fireflies, we journey nearly five times as far into the interstellar vastness to view another example of Andromeda's diverse cross section of deep-sky wonders. This is the bright compact planetary nebula NGC-7662. Sweep for it with a low to medium-power eyepiece on the telescope in the area of sky above the Great Square—a third of the way from Iota (ι) to Omicron (ο) Andromedae, half a degree southwest of the 5th magnitude star 13 Andromedae. One of the finest specimens of its class for small telescopes, this object was discovered by Sir William Herschel and carries his designation HIV-18 (or H184) on some star atlases like Norton's.

This lovely blue gem has a distinct disk that measures about 32 by 28 seconds in size and glows near 9th magnitude visually. Even at 30 power on a 3-inch scope, the planetary has a definite nonstellar look to it. The nebula is closely surrounded by several field stars which are excellent for critical focusing on the disk itself.

NGC-7662 is transformed from a

little blue dot in small instruments to a perforated disk with dusky center in 8 and 10-inch telescopes at medium to high powers. Like most planetaries, it has a very faint central star, this one variously listed as 12th to 16th magnitude. This tiny nucleus has been suspected of strange variations in brightness over the years, though some attribute this to seeing and/or contrast effects from the surrounding nebulosity. Concerning the possibility of a variable central star in this and other members of its class, Burnham stated: "The physical reality of such changes remains unproven."

The great observer E. E. Barnard, using the Yerkes 40-inch refractor, originally called attention to strange doings within NGC-7662. His description of its visual appearance in the great telescope reads in part: "...a beautiful object—a slightly elliptical disc with quite sharply defined outlines. Unsymmetrically placed on this is a roughly elliptical broken ring of greater brightness. The interior of this ring is dark but not black, and in this, approximately central, is ordinarily a faint stellar nucleus."

NGC-7662 was described as "remarkably bright, slightly elliptical" by Norton and as a "magnificent object" by the *NGC* itself. Barns saw it as "bright, bluish green, elliptical. Diameter 20 seconds. Variable nucleus and two oval rings." As usual, the most comprehensive account of this object is that left by Webb, who found it "small, but very bright. Lassell sees nucleus and 2 oval rings...My 9.3-inch (reflector) shows a bluish disk with woolly border and suspicion of dark center. Huggins, 8-inch (refractor): annular, greenish blue."

With the exception of a few "show off" members of the class like the Ring (M-57) and Dumbbell (M-27) Nebulae, planetaries take some getting used to compared to other deep-sky objects. This is mainly because of their relatively small apparent sizes—usually seconds of arc rather than minutes or even degrees for subjects like clusters and galaxies. Still, they are comparable to the dimensions of the various planets as seen in the telescope, and can be exciting and fascinating to look at even in a small glass. Being bright and easily found, NGC-7662 is an excellent object to cut your astronomical teeth on—give it a try the next clear night.

M-31, M-32 & M-110

We now take the ultimate leap into space—from viewing objects within our own galaxy to those well outside of it. Our target is one of nature's most imposing spectacles: a distant island

Selected Objects — Andromeda

Object	Type	Mag.	Size/Sep. Per.	R.A. (1950)	Dec.
*NGC-7662	■	8.9	32"x28"	23 ^h 24 ^m	+42° 14'
Σ 3050	★ ²	6.5,6.7	1"	23 ^h 57 ^m	+33° 27'
AQ	♂★	6.9-8.2	332 ^d	00 ^h 25 ^m	+35° 18'
Pi (π)	★ ²	4.4,8.7	36"	00 ^h 34 ^m	+33° 27'
*M-110	\$0	9.4	8'x3'	00 ^h 38 ^m	+41° 25'
*M-31	\$5	4.8	160'x35'	00 ^h 40 ^m	+41° 00'
*M-32	\$0	8.7	4'x3'	00 ^h 40 ^m	+40° 36'
36	★ ²	6.2,6.7	0.5"	00 ^h 52 ^m	+23° 21'
Σ 79	★ ²	6.0,6.8	8"	00 ^h 57 ^m	+44° 27'
NGC-404	\$0	10.7	2'x2'	01 ^h 07 ^m	+35° 27'
56	★ ²	5.7,5.8	190"	01 ^h 53 ^m	+37° 00'
*NGC-752	○	7.0	45'	01 ^h 55 ^m	+37° 25'
*Gamma (γ)	★ ³	2.3,5.5,6.3	10",0.5"	02 ^h 01 ^m	+42° 06'
59	★ ²	6.0,6.7	17"	02 ^h 08 ^m	+38° 48'

*Detailed in Close-Up

★ Star	♂ Regular Variable	○ Open Cluster	\$0 Elliptical Galaxy
★ ² Bright Star	♂ Irregular Variable	● Globular Cluster	\$5 Spiral Galaxy
★ Double Star		■ Planetary Nebula	\$/\$ Barred Spiral Galaxy
★ Triple Star	★ Eclipsing Variable	□ Bright Diffuse Nebula	\$* Peculiar/Irregular Galaxy

universe of stars visible to the unaided human eye on a dark (moonless) transparent night. This is the famed Andromeda Galaxy, Messier 31, the largest, brightest and nearest of all the spirals (apart from the Milky Way itself) and the finest representative of its class in the entire heavens.

To find this remote star city, locate the stars Beta (β) and Mu (μ) Andromedae — these point northwestward to its position just a degree west of 4th magnitude Nu (ν) Andromedae, where an elongated blur of light greets the eye on a good night.

Slow sweeping back and forth across the Andromeda Galaxy with binoculars or a rich-field telescope will reveal its size and brightness. Measuring 160 by 35 minutes is size (or about $2\frac{1}{2}^\circ$ in the longest dimension) on a typical photograph, its combined light is nearly that of a 4th magnitude star. Skilled observers using binoculars under superb atmospheric conditions (and taking special precautions to prepare the eyes properly) have repeatedly traced this spiral's glow to 1° by 5° in extent — or nearly 10 full moon diameters on the sky. And still, we are some 2,200,000 light-years away!

A 3 or 4-inch glass at 45 power shows a small but bright nucleus to M-31, surrounded by an eerie oval glow extending completely beyond the eyepiece field. This represents the blended light of hundreds of billions of remote suns orbiting the galaxy's core. Careful scrutiny using averted vision also reveals dark structures or rifts above and below the nucleus — areas where the nebulous glow suddenly ends — that represent dust lanes between the spiral arms themselves.

In 8-inch and larger instruments, the tiny galactic core looks starlike even at high powers, and the contrast between the luminous and dark regions seems enhanced. Again, averted vision and slow sweeping back and forth across the image with a low power ocular gives the best view of the dark structures.

Webb called the Andromeda Galaxy "one of the grandest in the heavens; long, oval or irregularly triangular, ill-bounded, and brightening to the center." Barns added that "the Great Nebula itself demands periodical observations under varying conditions to unfold the true glory of this celestial paragon" and called it a "fairly defined naked-eye spectacle; but in a telescope of low power and wide range (field), an object of increasing interest and wonder."

The noted Messier observer John Mallas described M-31 in part as follows: "The brighter portions of the

Above right: Many observers consider Gamma (γ) Andromedae the most beautiful multiple star in the sky, outranking even the more famous Albireo. Small apertures show Gamma Andromedae as double, but larger telescopes will reveal the fainter component as itself a close pair. Drawing by Dewey Schwartzenburg. Below right: The tiny planetary nebula NGC-7662 gleams like a blue gem in the sky. High powers with at least an 8-inch aperture are required to discern detail. Drawing by Tom Reiland.

arms form a flattened diamond-shaped figure. The central condensation appears very intense and starlike at low power. The 4-inch (refractor) at a magnification of 25 does not reveal a grainy central region, yet this visual characteristic was prominent ... in other galaxies of the Messier catalog."

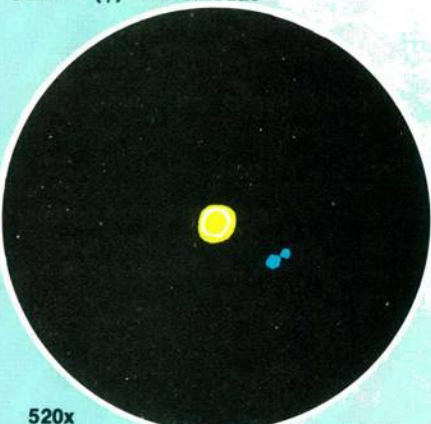
In addition to M-31 itself, this great galaxy has four small companions accompanying it — all dwarf systems of the elliptical type. Two of these (NGC-147 and NGC-185) lie about 7° to the north of the main object itself and are rather faint for small scopes. The other two lie close to M-31 and are within easy reach of even a 2-inch glass on a dark night. These are M-32 and M-110 (or NGC-205, the name it was solely known by until fairly recently when it was assigned a Messier number based on the fact it was seen and recorded by the great observer).

M-32 appears as a small, round and fuzzy spot about $\frac{1}{2}^\circ$ south of M-31's nucleus and has been seen even in binoculars. It is rated at 8.7 magnitude and measures about 4 by 3 minutes in apparent size. M-110 glows faintly near 9th magnitude (some sources, perhaps working from photographs, consider it as dim as 11th) and is about 8 by 3 minutes across. Its surface brightness is much lower than M-32's and it is often missed by beginning observers. Look for it just a degree northwest of M-31's core. All three galaxies can be seen in a 2.4-inch refractor at 30 power.

Webb described M-32 as "in the same low-powered field: small but bright," and remarked that M-110 appeared as a "large faint oval nebulosity best with low powers" and also that it "seems to sparkle." Barns logged M-110 as "large, oval, pearl white" and listed it as a diffuse nebula. Also puzzling is his complete omission of M-32 in his account, despite the fact it is a glaringly obvious feature in a telescope the size he was using.

Mallas saw M-32 as follows: "This beautiful galaxy is one of the best examples of an elliptical. Visually it has an oval form and bears magnification well. In the 4-inch, the brightness of M-32 is pretty uniform nearly to the

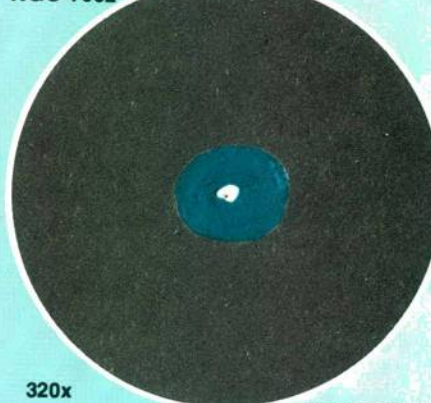
Gamma (γ) Andromedae



520x

4 1/4-inch refractor

NGC-7662



320x

6-inch reflector

edge; then it fades rapidly into the sky background." And M-110 was to him "an impressive sight in the 4-inch refractor. It is almost uniform in luster, with a brighter middle." He also mentioned for this object a "curious soft extension that was seen near the limit of perception" at the southern end of the major axis that other observers have seemingly overlooked.

As is the case with other deep-sky showpieces, it is fascinating and informative to compare time-exposure photographs of the Andromeda Galaxy and its companions with their telescopic appearance. You'll be surprised to find that a well-trained, dark adapted eye on a good night can glimpse much of the detail seen in the photos, even in a relatively small instrument. In fact, you may well see features not visible in the pictures themselves due to overexposure or the integrating effect of atmospheric turbulence. Best of all, you are actually seeing these vast swarms of stars, gas, and dust with your own eyes in "real time" — the original rather than a reproduction. Robert Burnham, Jr. has well observed in the introduction to his great *Celestial Handbook*: "And there is no privilege like that of being allowed to stand in the presence of the original." 🌌

SPACE '80

ASTRONOMY'S CALENDAR OF SPACE ART AND PHOTOGRAPHS

Space '80 features 12 full color varnished reproductions of the finest pictures from astronomy. More than a useful reference, it is designed to beautify your wall as a calendar or as individual pictures that you can frame. Each picture is accompanied by a brief clear description, and can be removed at the end of the month and framed — the quality is that good! From Jupiter to the Orion nebula to galaxies in deepest space, you can enjoy the wonders of space every day of the year!

\$5.95

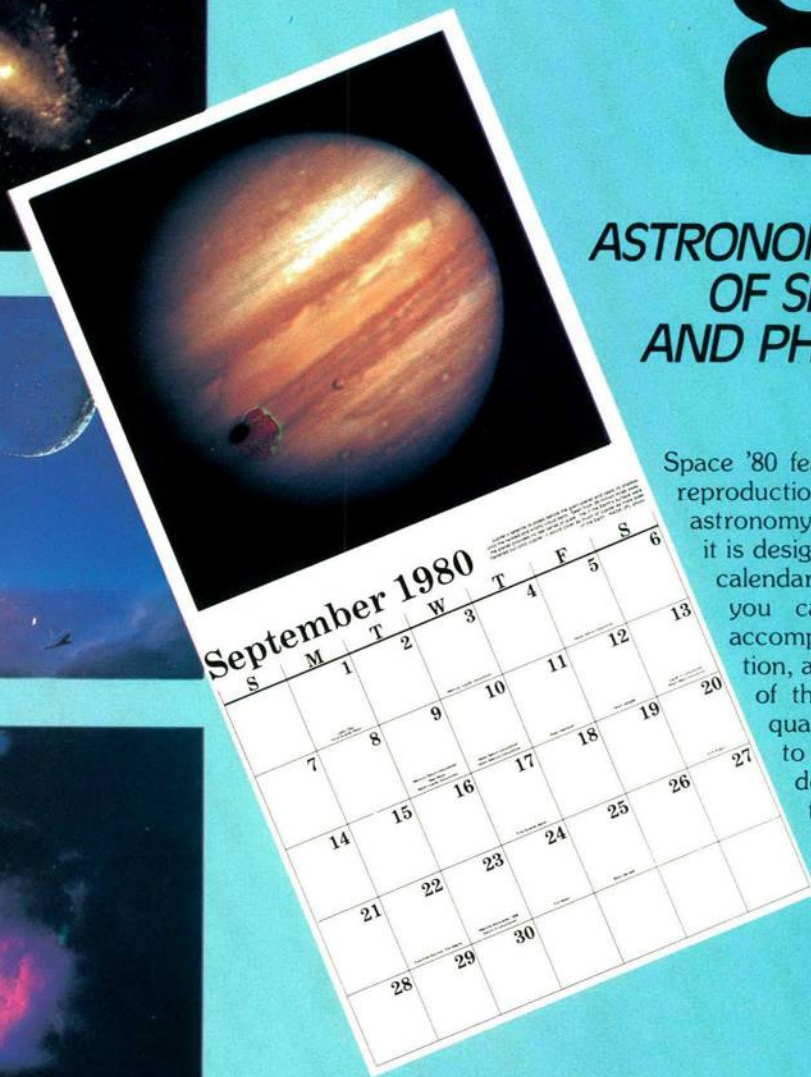
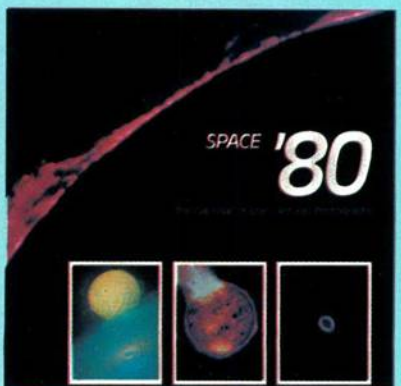
includes postage & handling

IN STOCK FOR FAST DELIVERY

- Printed in full color on 80 lb. paper, fully varnished images
- Punched for easy hanging
- Planet oppositions, eclipses, elongations and dozens of other special sky events noted
- Room for notes, birthdays & appointments
- Added Bonus: Galaxy Gallery and 3-year calendar
- Buy 3 for Christmas giving, and we'll give you the 4th FREE!

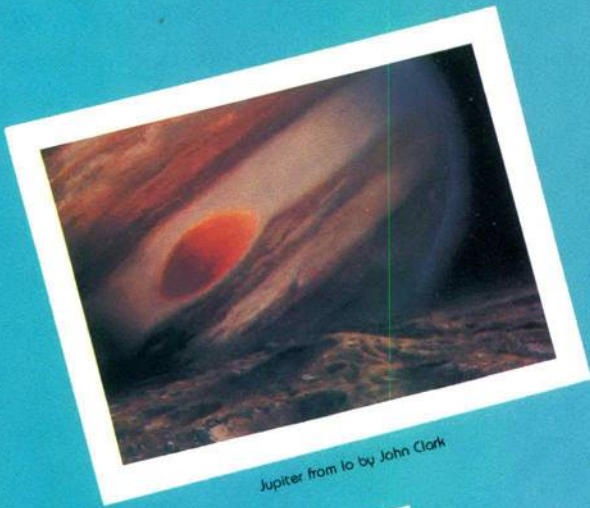


To order use form bound into this magazine.



★ POSTER ★ CLEARANCE

The guys in the stock room have been stumbling over these for months, and now that we've got new posters coming in, we really need the room! Buy them now, because once they're gone, you'll never see them again!



Jupiter from Io by John Clark

98¢

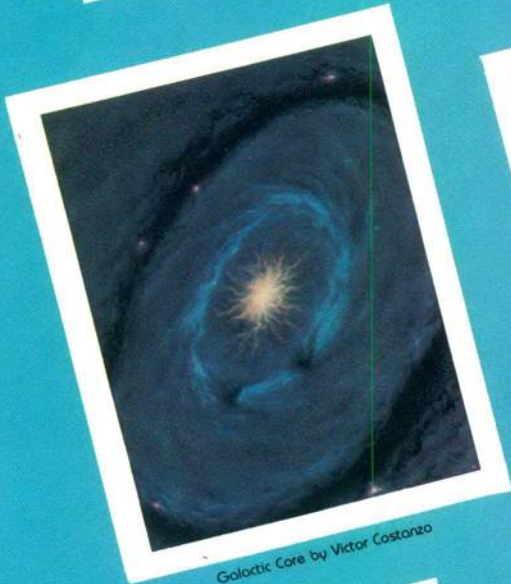
each

originally \$2.00

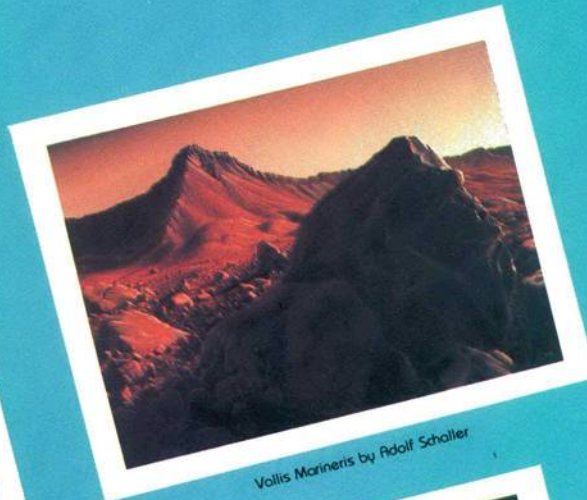
All 6 For \$5

While They Last

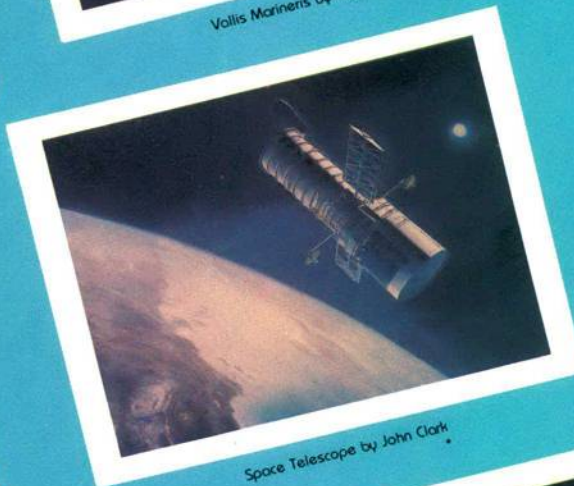
Add 75¢
Per Order
For Postage



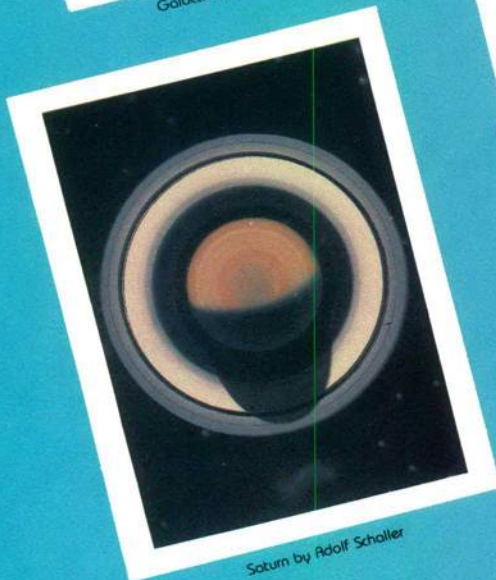
Galactic Core by Victor Costanzo



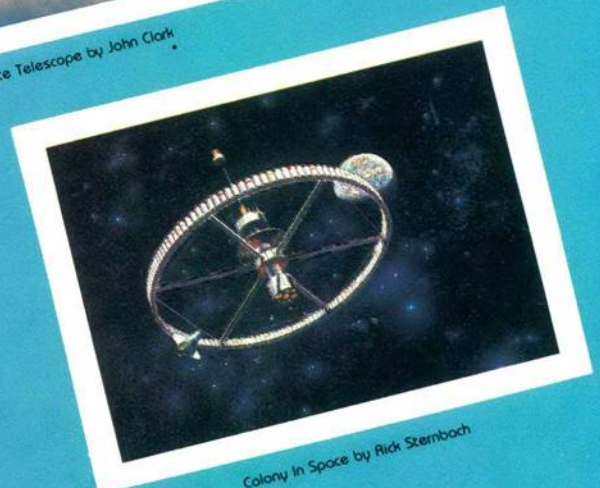
Vallis Marineris by Adolf Schaller



Space Telescope by John Clark



Saturn by Adolf Schaller



Colony in Space by Rick Sternbach



To order use form bound into this magazine.

Celestron takes you to the moon...and back.

Did you know that there are extraordinary ruptures featured in the moon's crust, called rills, and extinct lava fields? You can study these as well as the awesome crater fields, dramatic ray structures, the Alpine Valley and even the "Great Wall" of the moon from your own backyard with your Celestron telescope. You can easily attach your 35mm SLR camera to your Celestron to permanently record for your own collection a complete phase study or attach the Tele-Extender and fill the entire negative with a single crater by eyepiece projection.



Celestron®

Celestron International
2835 Columbia St., Box 3578-B
Torrance, Calif. 90503, U.S.A.
Telephone: (213) 328-9560

Free 4-page brochure or send
\$2.00 for 32 page full color
catalog on how to select and
use a Celestron telescope/
telephoto lens.

CELESTRON 8 TELESCOPE



NGC 2237-9 Rosette Nebula photographed by 5½ inch Schmidt camera on the Celestron 8 to expand your horizon beyond our solar system.